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INDIAN AGRICULTURAL
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REPORT

ON THE

IMPROVEMENT OF INDIAN AGRICULTURE.

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PREFACE.

WHAT was intended to be a short Report on the Improvement Indian Agriculture has, owing to the comprehensiveness and portance of the subject, become expanded into a volume of ver 400 pages.

I have not attempted any description of the crops or of the ethods of agriculture pursued, but have endeavoured to confine yself to matters in which I believe that Improvement can be fected.

While the conclusions I have formed are the result of my vn personal observation, I am yet very deeply indebted to hers for the information I have collected, and in particular, to e Government of India and its officials for the exceptional vantages I have enjoyed.

I desire to return publicly my sincere and grateful acknow-dgments.

Kensington, London, W,
March 1893

J. A. V.

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ual licences for the removal of wood, etc., for agricultural s. These views are supported by the quoted opinions of several thorities, and more especially by a recent Resolution of the dras Government upon the subject. Cases are also cited ere such "reserves" have been created, and have achieved ch good. It is maintained that the success of such a scheme st not depend alone upon financial considerations, but should considered from the point of view of the needs of the people l the demands of the principal industry of the country, *viz.*, iculture. Extension of the establishment of plantations along al banks and railway lines is also urged, and the further couragement of arboriculture. Lastly, the opinion is expressed t a proportion of the yearly revenue obtained by the Forest partment should be expended in the extension of the work of Department in an agricultural direction.

RECOMMENDATIONS.

recommend (1) the creation of "reserves" of wood, fuel, ., for agricultural purposes ("Fuel and Fodder Reserves"); the increase of plantations along canal banks and railway es; (3) the further encouragement of arboriculture; (4) prosecution of agricultural enquiry for ascertaining the ds of the different cultivating districts in the matter of wood ply; (5) the setting aside yearly of a portion of the enue derived by the Forest Department, and its employment he extension of "reserves" to meet agricultural wants.

CHAPTER IX.

CHAPTER IX.

GRASS.

GRASS.

HE different kinds of grazing areas available for the use he cattle belonging to cultivators are referred to, and ntion is drawn to the inclusion of large and valuable grazing s amid the forests. It is maintained in this chapter that the ision of grazing in forests is a desirable and legitimate object, one which will much benefit agriculture, whilst in times of ght it may be invaluable in keeping the cattle of the country . Nevertheless, it is not regarded as an absolute necessity in ary times, and, therefore, should only be carried on under such ictions as would cause it not to interfere with the other ends a forest or "reserve" should serve. These various restricand the necessity for their imposition are then considered. question of the utilisation of "village wastes" is next gone also the provision of grazing along canal banks and in other tions. The best way of utilising the grass in forests and rves," and the possibility of grass-growing and the supply sturage becoming a part of the cultivator's system on his olding are discussed. In the second part of the chapter the of Grass Farms and the utilisation of uncultivated grass lands (*rukhs*) belonging to Government are explained, and, wl their benefits are recognised and their extension urged, suggestic are also made for their improvement. The methods of hay-maki and silage-making as conducted at Government Grass and Expe mental Farms are examined, also the relative costs compared w the cost in England. The prospects of the development silage-making in India are treated of and the desirability is urg of making further enquiries at Experimental Farms. Lastly change is advocated in the Commissariat Department, where the services of men of experience and ability may be retained the management of Grass Farms, and the formation of a speci Forage Branch of the Commissariat is suggested.

RECOMMENDATIONS.

I recommend (1) the creation of more "Fuel and Fodd Reserves" to supply grass and grazing; (2) the extension of t system of Grass Farms, and their management by a special Fora Branch of the Commissariat; (3) the carrying out of enquiry Government Experimental Farms on the making of silage.

CHAPTER X.

CHAPTER X.

FODDER-CROPS AND HEDGES.

FODDER-CROPS AND HEDGES.

THE advantages of growing fodder-crops are set forth exemplified in the better condition of the cattle in many p where the system is practised. The principal crops used fodder-crops are mentioned, and, in particular, the utilisatioı prickly pear. The scope for extension of the growing of fodd crops is also shown. It is pointed out that but little is known a the relative values of different Indian fodders, and that such investigation calls for the association of an agricultural chen The useful ends served by hedges round fields are explained, the materials generally used for fencing are named.

RECOMMENDATIONS.

I recommend (1) the extension, wherever practicable, of systems of growing fodder-crops and of enclosing fields hedges; (2) the employment of an agricultural chemist in ir tigating, among other matters, the relative values of diffe fodders.

CHAPTER XI.

CHAPTER XI.

LIVE STOCK AND DAIRYING.

LIVE STOCK AND DAIRYING.

It is indicated at the opening of this chapter that, since the ifferences between the cattle of different districts are largely ue to conditions of climate, improvement of cattle is only pos- ble within limits. After speaking of their food and the excel- nce of the cattle in certain districts, it is shown that, as a rule, ttle or no attention is paid to their breeding and selection. The indu system of breeding from Brahmani bulls is referred to, nd the harm is pointed out which is likely to follow from a ecent legal decision given in the North-West Provinces as to wnership in these bulls. The breeding of good stud bulls at overnment Cattle Farms, and the distribution of them to villages, e advocated, and should form part of the duty of Agricultural epartments. Further, I point out that Experimental Farms nd Court of Wards' Estates might well be made centres for cating stud bulls for the improvement of the cattle of e district. Accounts are next given of the Hissar and hadgaon Cattle Farms, and mention is made of the influence hich they, and notably the former, have exercised on the cattle the country. The evils attending frequent changes in the perintendence of Government Cattle Farms are pointed out, they were in the case of Grass Farms (Chapter IX). ntion is made of the use of buffaloes as plough cattle, and of giving of advances (*taccavi*) for purchase of cattle.

n the second section of the chapter dairying is the main sub- t, and the special features of the yield and quality of milk m cows and buffaloes are treated of. The efforts made to tend dairy farming in India are detailed in connection with the sit of Mr. Howman, and the subsequent steps taken by Mr. Ozanne Poona and Bombay. The unsatisfactory conditions of the milk pply to towns and to troops, as well as to Government institu- ns, are referred to, and the establishment of Dairy Farms is vocated wherever troops are quartered or large institutions are uated. It is pointed out that there is considerable work for agricultural chemist to do in the investigation of points con- ted with dairy farming.

A brief reference is made to the operations of the Horse- eding Department, and to attempts made to improve sheep goats.

The last part of the chapter is taken up with the consideration Cattle Diseases, the ravages which they cause, and the steps ich have been here and there taken to cope with epidemics. cial mention is made of the establishment of an Imperial teriological Laboratory at Poona.

RECOMMENDATIONS.

recommend (1) the continuance and extension of Cattle ms, and the distribution from them of stud bulls to villages; the making Experimental Farms and Court of Wards' ates centres for the location of stud bulls; (3) the establishment of Dairy Farms for the supply of milk to troops an Government institutions; (4) the appointment of an Agricultur Chemist to investigate matters connected with dairy farming (5) the prosecution of enquiry into cattle diseases and the mea of preventing epidemics.

CHAPTER XII.

CHAPTER XII.

IMPLEMENTS.

IMPLEMENTS.

THE possibility of effecting improvement in the implements o the cultivators is reviewed, and the opinion is expressed tha there is but little scope for improvement, and that any advanc must be the outcome of a study of native requirements. Th success of the Beheea sugar-mill is instanced as a case in poin The question of the use of the native wooden plough, as agains that of the iron one, is fully gone into, the several objections t iron ploughs being discussed, and the circumstances under whic they might be usefully employed. The chapter then deals wit the introduction and possible extension of the iron sugar-mi the shallow evaporating-pan, and other devices for improvi the out-turn of sugar. The possible use of introduced threshi machines, winnowers, chaff-cutters, pumps, and other implem is considered, and the need of more exhaustive trials of imp ments at Experimental Farms is urged. It is added that in th trials skilled experts, such as engineers, chemists, &c., should associated, according as the enquiry calls for it, and that Expe mental Farms should be centres for distributing implements t merits of which have been satisfactorily proved.

RECOMMENDATIONS.

I recommend (1) the exhaustive trial of new implements Government Experimental Farms; (2) the association "experts" in such enquiries; (3) the distribution of approv implements from Experimental Farms.

CHAPTER XIII.

CHAPTER XIII.

CROPS AND CULTIVATION.

CROPS AND CULTIVATION.

IN this chapter no attempt is made to describe the kinds of
rops grown, or the methods of cultivation employed, but points
ly are discussed in which it seems possible to effect improve-
ent. The general excellence of the cultivation is indicated,
nd the changes, more especially in wheat-growing, which have
een brought about by an export trade, are mentioned. Fallowing
nd rotation are next taken, and instances are given to show that
e native cultivator is not ignorant of either practice. The
ystem of "mixed-cropping" is also explained, but it is pointed
ut that little is known or practised in regard to selection or
hange of seed, although some Government Experimental Farms
ave already done good work in growing and distributing pure
d selected seed. It is then shown that improvements can be
ected by the introduction of new crops, and of new varieties
existing crops, as also in the extended cultivation of certain
ofitable crops, such as wheat and sugar-cane. It is further
monstrated that by the transference of method from one part
another, improvements in cultivation may be carried out;
s is exemplified in the case of sugar-cane, and even in that of
crop so widely cultivated as rice. Reference is made, in
clusion, to the need that exists for getting more knowledge
the diseases and injuries to which crops are liable, and the
t means of preventing them.

RECOMMENDATIONS.

recommend (1) the continuation of experimental enquiry
Government Farms, in reference to new crops and methods of
ltivation; (2) the growing of good seed at Government Farms,
d its distribution from them; (3) the study of the diseases
d injuries of crops; (4) agricultural enquiry into existing
des of cultivation.

CHAPTER XIV.

AGRICULTURAL INDUSTRIES AND EXPORTS.

AGRICULTURAL INDUSTRIES AND EXPORTS.

THIS chapter deals with certain special crops which underg process of manufacture in the country before being sent out it, or with which particular considerations regarding export a bound up. Such crops are sugar-cane, cotton, indigo, tea, coffe tobacco, flax, jute, silk, wheat, and linseed. These crops a successively treated in view of the improvements which it possible to effect either in their cultivation, their manufactu or in the export trade. It is first shown that the yield of sug from sugar-cane depends upon points in the cultivation, in t expression of the juice and in its refining, none of which are ful understood. Next, the deterioration of Indian cotton is allud to, and a brief account is given of the efforts that have be made to improve its quality. Indigo is treated at some lengt and the general want of knowledge, both as to its cultivation a the manufacture of the dye, is commented on. Reference made to the need of chemical investigation into problems affecti the manufacture, and to the unsatisfactory conditions which oft attend the cultivation. Similarly, chemical problems in manufacture of tea are pointed out. The cultivation of cof is next taken, then that of tobacco, and the native method curing tobacco is described. After a brief mention of flax jute, allusion is made to the efforts, so far unsuccessful, eradicate the disease in silkworms known as *pebrine*. The portant matter of the cleaning of wheat is dealt with at le and by the help of analyses which I made of samples take the cultivators' own threshing-floors, or from stores in t houses, it is shown that the fault attributed to Indian whe that it is "dirty," does not rest with the cultivator, but is that the trade, and more particularly the London Corn Trade, who not want "clean" wheat. The efforts made to improve the tr in this respect, and their failure, are described. The applicabi of the "elevator" system to India is also discussed. Lastly, conditions of the linseed trade are explained, and are illustr by analyses of a number of samples of seed collected for m the Central Provinces.

RECOMMENDATIONS.

I recommend (1) agricultural enquiry to ascertain the methods of cultivation and manufacture of crops such as sugar-c indigo, tea, coffee, tobacco, &c.; (2) the employment of chem science in the investigation of problems affecting these indust and more especially that of an agricultural chemist in connec with the sugar industry; (3) the making it a penal offenc adulterate wheat, or to trade in adulterated wheat.

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CHAPTER VII.

MANURE.

THE importance of manure in Indian agricultural systems is illustrated by extracts from various Reports, and the interdependence of water and manure is shown in the existence of the finest cultivation where both water and manure are available. Instances are given to show that the cultivator is not ignorant of the value of manure, but will, for certain crops, spend considerable sums of money upon it. The different sources of manurial supply are then examined, the ordinary cattle-manure being the most important, and, speaking generally, the only one available. Its composition is set out in analytical tables, and a comparison is instituted between it and ordinary farmyard manure, as met with in England, the result being to show that the value of Indian cattle-manure is often underrated, and that when it is burnt (as is so often the case) very serious loss is incurred. As the outcome of an enquiry in which I specially interested myself, I state the conclusion I came to, *viz.*, that the best cultivators do not burn cattle-manure for fuel except from necessity, that is, because they have nothing else to burn as fuel. The connection between the supply of firewood and that of manure is hence a very close one. Other sources of manurial supply are then dealt with in succession, *e.g.*, ashes of cattle-manure, sheep-folding, green-manuring, silt, soil-mixing, oil-seed refuse, nitre, lime, bones, &c., and various analyses of different materials so used are given in the Appendix. Special questions, such as the system of seed-bed cultivation known as *ráb*, the use and export of bones, and the likelihood of artificial manures being used in India, are treated in detail. Attention is then drawn to two points in which the cultivator does not take full advantage of the facilities he possesses (1) the non-utilization by him of night-soil for agricultural purposes; (2) the imperfect conservation of cattle-manure and the loss of the urine. In this connection instances are given of the highly beneficial results that have attended the use of night-soil, and analyses are given showing the value of cattle urine and the advantages to be gained by preserving it by the aid of litter. Incidentally, questions of town and village sanitation are touched upon, and throughout the chapter there are frequent references to investigations which could not be carried on without the aid of agricultural chemistry. In conclusion, it is maintained that water and manure constitute the cultivator's chief wants, and that the supply of manure must go hand in hand with that of water, and must, like the latter, be taken up by Government, otherwise the soil will not be able to provide for the increasing millions of the people. It is further held that, as cattle-manure is the only really available manurial source, it is incumbent on Government to provide supplies of firewood ("Fuel and Fodder Reserves") so that the cattle-manure need not be burnt, but may be set free for use on the land, and the fertility of the latter be thereby kept up.

Lastly, I set forth the duty of Agricultural Departments to make organised enquiry as to the manurial requirements of every district, to continue experimental research at Government Farms, and to spread agricultural education so as to teach better practices and remove prejudices.

RECOMMENDATIONS.

I recommend (1) the creation of supplies of fuel ("Fuel and Fodder Reserves"); (2) the establishment of a system of agricultural enquiry; (3) the spread of agricultural education; (4) the continuation of experimental work at Government Farms; (5) the employment of an agricultural chemist.

CHAPTER VIII.

CHAPTER VIII.

WOOD.

WOOD.

THIS chapter deals principally with the administration of the Forest Department and the extension of its work in a more agricultural direction than has been the case in the past. The early policy of the Department is first considered, and the reasons are given for its success having been gauged by financial results. But it is pointed out that, as population has increased and cultivation has been brought nearer to the borders of the forests, it has become necessary to extend the benefits of forests, so that they may more directly serve the interests of agriculture. In consequence of this, at the instance, first of Sir Dietrich Brandis, and then by successive representations of the Famine Commissioners and of the Government of India, a certain impulse has been given to the supply of wood for agricultural purposes. But it is urged in this chapter that there is a great deal more that ought to be done, and that the greatest need is that which was set out in the previous chapter, *viz.*, the supply of wood to take the place of cattle-manure as fuel. This is again put forward as a matter which Government should see to in their own interests, alike for the maintenance and increase of the soil's productiveness, as well as in order to keep up the Land Revenue of the country. The different classes of forests are then examined, and the uses which they might best serve are discussed, also the measures which should be taken to obtain those ends. Special points, such as the natural reproduction of timber trees, the guarding against forest fires, the exclusion of grazing, and the inadequacy of the forest staff, are alluded to separately. The wider adaptation of "reserved forests" situated near cultivation to the purposes of that cultivation is insisted on, and also the necessity of creating fresh supplies of wood. The difficulties of obtaining land for these new creations are admitted, but it is shown that there is still a quantity of land that could be so utilised, and suggestions are made for the acquirement of land, by purchase if necessary; the outlines of a scheme are also set forth for the working of the new "reserves" by a system of weight to proficiency in natural science. It is then suggested that junior Civilians, or at least a proportion of them, should, on arrival in India, be drafted into provincial Departments of Land Records and Agriculture, there to learn something about the country, the people, the crops, and the agricultural conditions generally, and that at their departmental examinations they should be required to show an acquaintance with these subjects. It is held that Directors of Agriculture should be chosen from the men who have shown a liking for natural science, and who have distinguished themselves subsequently by their knowledge of agricultural matters. The position of the Director of Agriculture is reviewed, and it is urged that it should be invested with some administrative power, and that the Director should form a part of the Revenue Administration. The giving to the Agricultural Department of a share in the administration of Government advances (*taccavi*) for well digging is again advocated. The necessity that Directors of Agriculture should tour in their districts is insisted upon, and is made applicable in a special way to the Secretary of the Imperial Department of Agriculture. The useful purposes which occasional Conferences on agricultural questions can serve are also exemplified. The classification of the work of Agricultural Departments is then referred to, and the main heads are briefly noted. Among them the importance of "analysis of districts" and the desirability of making a digest of the Land Records are put forward. Agricultural Shows are treated at some length, and suggestions are made for their improvement, as also for the better conduct of trials of implements.

In conclusion, the future policy of Agricultural Departments is discussed, and the two great needs—a competent organization, and the expenditure of more money upon agricultural improvement—are put prominently forward. Lastly, uniformity of purpose and continuity of policy in the work of Imperial and Provincial Agricultural Departments are strongly urged.

RECOMMENDATIONS.

I recommend (1) the giving of more weight to natural science in the open competitive and final examinations for the Civil Service; (2) the drafting of a certain proportion of junior Civilians into the Department of Land Records and Agriculture on their arrival in India; (3) the selection of Agricultural Directors from those who have distinguished themselves in natural science, and subsequently by their agricultural knowledge; (4) the giving of some administrative powers to Agricultural Directors, and, especially, that a share of the administration of Government advances (*taccavi*) be entrusted to Agricultural Departments; (5) the granting of more money to be expended by Agricultural Departments in the work of agricultural improvement.

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RECOMMENDATIONS

I conclude the chapter by recommending (1) the spread of General and Agricultural Education; (2) the establishment of an organised system of Agricultural Enquiry; (3) the active prosecution and encouragement of positive measures, such as the supply of water, wood, &c., which have already been found to be beneficial.

CHAPTER III.

CHAPTER III.

CULTIVATING CLASSES.

CULTIVATING CLASSES.

It is pointed out that certain "castes" and "races" of the people of India show more agricultural ability than others, and that the differences between them as cultivators are in great measure to be referred to the caste or race distinctions existing between them. It is very certain that if the prejudices attaching to caste and race could be broken down, considerable improvement in agriculture would result. Instances are next given which show indications of a change slowly going on. Thus, the prejudices against the cultivation of indigo and of the potato have, to a great extent, disappeared: also the cases of Nagpur, Poona and Amritsar are mentioned as showing that the prejudice against the use of night-soil as manure for crops is giving way. Improvement in coffee cultivation and in the manufacture of indigo, as the outcome of the example of English planters, is also distinctly traceable. The people, it is pointed out, will lose those caste prejudices which retard improvement in agriculture, partly through the spontaneous adoption by them of the more profitable practices, and partly from the force of circumstances which make living harder and oblige more attention to be paid to cultivation. In the weakening of caste prejudice Education is a most important factor, and Government by spreading it will help to break down the caste distinctions which prevent progress in agriculture.

RECOMMENDATION.

I therefore advocate the spread of General and Agricultural Education.

CHAPTER IV.

CLIMATE.

CHAPTER IV.

CLIMATE.

WITH the aid of the "Rainfall Map" included in the Report, the great variations of climatic conditions throughout India are illustrated, and their bearing is shown upon the crops grown, the agricultural systems pursued, the cattle, and even the people themselves. The close connection of famine with the rainfall is also set forth It is pointed out that while it is to only a limited extent that climatic differences can be modified, yet that something can be done by increasing the means of irrigation in dry tracts, and by the creation of "reserves" of wood and fodder in districts where these are scarce. The influence of vegetation, and especially of trees, in improving climate is discussed; the real value consisting in the lowering of temperature, the production of a more gentle rainfall, the increase in the number of rainy days, the holding-up of the soil, the obtaining of a cooler earth-surface, and the retention of moisture by the soil.

It is maintained that such work must fall to the lot of Government, and that the people can be expected to do but little to aid it. Encouragement is, however, given to tree-planting by individuals, and this should be prosecuted more vigorously. It is further insisted that in order to get definite knowledge as to where provision of irrigation and "reserves" of wood and fodder can be made, careful enquiry must be set on foot by Agricultural Departments.

RECOMMENDATIONS

I recommend, accordingly, (1) the extension of irrigation to dry tracts; (2) the creation of "reserves" of wood and fodder (called "Fuel and Fodder Reserves"); (3) the planting of trees along canal banks and railway lines; (4) the further encouragement of Arboriculture; (5) organised enquiry by Agricultural Departments with the view of finding out where the foregoing measures can be adopted.

CHAPTER V

SOIL.

CHAPTER V.

SOIL.

THE principal geological types of soil which occur in India are illustrated by the help of the "Geological Map" accompanying the Report, and the presence or absence of particular kinds of soil are indicated. The neglect, in the past, of any regular scientific study of Indian soils is referred to, and the important question is next dealt with—whether or not the soil of India is becoming exhausted under the present systems of cultivation. It is admitted that there is want of positive evidence in support of exhaustion, but instances are given from Settlement Reports and from the Famine Commission's Report, of a process of deterioration going on, and it is argued that under existing conditions of export of grain, oil-seeds, and manures, and the burning of cattle-dung for fuel, there must be a gradual deterioration of the soil. The wheat-yield of India is compared with that of other countries, and Sir James Caird's estimate of the crop-increase needed to provide against famine is alluded to, and the deduction is drawn that to supply this amount, not a *deterioration* but an *increased productiveness* of the soil is required, and that this can only be brought about by increasing the manure supply. The soils of India are then considered in respect of the different constituents which they contain, each ingredient being taken in turn. It is shown how important is the relation of water to soil, that organic matter (*humus*) and nitrogen are generally deficient in Indian soils, and that lime, potash and phosphoric acid are, as a rule, present in sufficiency. Several chemical questions of great importance are dealt with, such as the supply to plant life of nitrogen from atmospheric sources, the amount of nitrogen contained in the rainfall of India, the nature, occurrence and possible removal of saline deposits in soil, &c. The reclamation of land, whether it be ravine land, land infested with weeds, or land rendered sterile by the presence of salts (*usar* land), is dealt with, and instances are given of the various experiments which have been tried in different places. Throughout the chapter it is shown that the application of chemistry to the solution of the various agricultural problems connected with the soil is very necessary, and it is urged that future investigation should be pursued with its assistance.

In conclusion, it is pointed out that the work of soil improvement must devolve mainly upon Government, as in very few cases will the people have the means to take such measures in hand.

RECOMMENDATIONS.

I recommend in connection with the improvement of the soil, (1) the increase of the supply of water to dry tracts; (2) the increase of the manure supply; (3) the setting on foot of enquiry to ascertain where such improvements are needed; (4) the continuation of experimental research aided by chemical science.

CHAPTER VI.

CHAPTER VI.

WATER

WATER.

It is indicated, at the outset, that while water in one form or another is indispensable in Indian agriculture, the amount and the method of supply will vary very greatly in different parts of India. In some parts rainfall is sufficient, in others artificial irrigation will be a necessity, in others, again, it may be a useful supplement. The nature of "protected" and "precarious" tracts is pointed out. The main types of water supply are summarised and then examined *in extenso*. Special points are noted, such as the benefits and the evils attending the introduction of canals, the comparison (where it is possible to make it) between cultivation by canal irrigation and by well irrigation, the differences in chemical composition between canal water and well water, &c. Embanking and drainage of land are spoken of, and instances are given of parts which stand in need of further irrigation. The great work done by Government in extending canals is favourably reviewed, and direction is turned to the necessity of Government undertaking all works of a major character, while minor ones may be carried out by the people. The possibility of Government constructing wells on a large scale is discussed, and improvements are suggested in the management of canal watercourses and tanks, and in the repair of the latter. The chapter goes on to treat fully of the system of advances known as *taccavi*, principally for purposes of well digging, and it is shown how greatly this is capable of further development, and of being made more popular and useful. It is maintained that the Agricultural Department should pay particular attention to this subject, and that a certa share of the administration should be vested in the Departme Suggestions are made as to improvements in the working of t system. Lastly, the necessity of a thorough "agricultural ana sis" of each district of the country is insisted on with the view of ascertaining the local requirements in the way of water supply.

RECOMMENDATIONS.

I recommend (1) the further extension of canals and other means of irrigation to tracts where they are required; (2) the more energetic working and popularising of the system of *taccavi* advances for well digging and similar purposes; (3) the giving of a share in the administration of *taccavi* advances to Agricultural Departments; (4) the institution by Agricultural Departments of organised enquiry to ascertain the irrigation requirements of each district.

CHAPTER XV.

CHAPTER XV.

ECONOMICAL AND POLITICAL CONDITIONS.

ECONOMICAL AND POLITICAL CONDITIONS.

BY the insertion of this chapter I wish to recognize the existence of a number of conditions of an economical or political nature which have an important bearing upon the improvement of agriculture, but into the details of which I do not enter. Under this head I mention pressure of population, relative ease or difficulty of living by agriculture, varying systems of land tenure, smallness of holdings, paucity of capital, indebtedness of the cultivating classes, export trade, extension of railways, &c. My reasons for not discussing these several points are given, the only ones mentioned at any length being the smallness of holdings, the indebtedness of cultivators, and the lack of enterprise sometimes found among the people, more especially under easy circumstances of living.

CHAPTER XVI.

CHAPTER XVI.

PRACTICAL ENQUIRY.

PRACTICAL ENQUIRY.

AFTER having sketched out in the previous chapters the principal ways in which I think that improvement of agriculture may be effected, I proceed to consider in those that follow, the agency by which the improvements are to be carried out. A brief review of the recommendations already given points to the conclusion that the main advance will be made by a practical enquiry into native agriculture, with a view to ascertaining (1) the requirements of each district in respect of water, wood, manure, and other facilities; (2) the best native methods of cultivation, in order to transfer them to other districts where they are not practised. A number of opinions in support of this view are quoted, and it is then pointed out that, up to the present, enquiry has been limited to the collection of Land Revenue statistics, and that there has been no organisation for enquiry into agricultural methods with a view to agricultural improvement. A large field for enquiry is then sketched out, and the necessity of an agency of an expert nature is urged. The opinions of the Famine Commissioners, the Government of India and Provincial Governments, on this point are quoted. The existing agency is reviewed, and more particularly the position occupied by the Director of the Department of Land Records and Agriculture in a Province. The lack of technical knowledge in the Department is brought out, and it is suggested that this want could best be supplied by associating with the Director of the Department in any Province a certain number of agricultural experts to be engaged on purely agricultural work. It is then discussed whether these experts should be Europeans or

Natives, and the conclusion is come to that, on the whole, the selection of Natives trained in India would be best, provision being made for the giving of a high-class agricultural education in the country itself.

RECOMMENDATIONS.

I recommend (1) the organisation of enquiry into agricultural conditions and practices; (2) the association with the Director of an Agricultural Department of one or more assistants who are experts in agriculture; (3) the selection of these assistants from Natives of India trained in the country itself; (4) the provision of a high-class agricultural education in India.

CHAPTER XVII.

SCIENTIFIC ENQUIRY.

CHAPTER XVII.

SCIENTIFIC ENQUIRY.

THE close connection of science with practice in any scheme of agricultural improvement is, at the outset, put forward, and the necessity is shown that practical enquiry should be scientific in its methods. The relation of chemistry to agriculture is then pointed out, and reference is made to the expressed opinions and renewed applications of the Government of India on the desirability of having an Agricultural Chemist for India. The scope of work for an agricultural chemist is then sketched out, and the principal duties of the office are defined as being the acting as "referee" or adviser to Government in chemico-agricultural matters, and the direction and maintenance of the continuity of enquiry. Among other duties are those of assisting in the development of agricultural education and the preparation of suitable text-books. The necessary qualifications to be possessed by the holder of such an appointment, and the conditions essential to his successful tenure of it, are defined. The existence of a suitable laboratory, and the co-operation of an assistant chemist (to take actual charge of the laboratory and to give instruction in agricultural chemistry) are regarded as essential. The relations, respective duties and salaries of the two officers proposed are discussed, and it is recommended that neither of them be allowed to undertake private work for separate remuneration. It is urged that not only an agricultural chemist, but also other scientific men, such as a botanist, an entomologist, and an agricultural engineer, should be associated with the Agricultural Department for the purpose of conducting enquiry and research, The chapter closes by dealing generally with the position of scientific men in India, the encouragement of scientific research, and, in particular, the appointment of Chemical Examiners.

RECOMMENDATIONS.

I recommend (1) the appointment of an agricultural chemist as adviser to Government in chemico-agricultural matters, and for the direction of experimental enquiry; (2) the appointment of an assistant chemist; (3) the attachment to the Agricultural Department of other scientific officers, such as a botanist, an entomologist, and an agricultural engineer.

ABSTRACT OF REPORT.

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CHAPTER I.

HISTORICAL INTRODUCTION.

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HISTORICAL INTRODUCTION.

THE opening chapter deals briefly with the history of Agricultural Departments in India since their establishment by Lord Mayo in 1871.

The failure and abolition of the first Agricultural Department in 1878, and its reconstruction in 1881 as the outcome of the Report of the Famine Commissioners of 1880, are touched upon, and the steps taken by the Government of India in carrying out the recommendations of the Famine Commission are reviewed. It is pointed out that the Government of India, in their Resolution of December 1881, clearly recognised the importance of the systematic prosecution of agricultural *enquiry* which had been so strongly urged by the Famine Commissioners, and that the Government of India, considering that these duties of the Department must precede any attempt at agricultural *improvement*, had first set about the work of "Land Revenue Organisation," hoping thereby to lay the foundation of all knowledge of the agricultural condition of the country.

The Land Record system, the importance of which was established by the enquiry of the Finance Commission of 1887, is then summarised. The reasons, of which the chief was financial pressure, why the further recommendations of the Famine Commissioners in regard to agricultural improvement were not taken up are briefly shown, but it is added that the Agricultural Department have not failed to recognise the obligation still resting upon them to take measures for agricultural improvement, as well as the further obligation, imposed on them by the Home Department in 1889, to promote agricultural education. It is next pointed out that the Agricultural Department, having, by means of the Famine Code, made provision against the difficulties of famine, and having organised the Land Record system, are now prepared to take up the question of agricultural improvement.

In this connection it is stated that the assistance of a first-class Agricultural Chemist has been urged repeatedly since 1882, both by the Government of India and by Agricultural Conferences which have met in India, and that finally Her Majesty's Secretary of State consented in August 1889 to send out an agricultural chemist to make enquiries in India itself, and to advise upon the course to be pursued, as also to report upon the possible improvement of Indian Agriculture. For this duty, I was, on the recommendation of the late Sir James Caird, selected.

The remainder of the chapter is taken up with a summary of my tour, the plan I adopted in pursuing my enquiry, and the expression of my special obligations to those who so largely assisted me in my work.

CHAPTER VII.

CHAPTER VII.

MANURE.

MANURE.

THE importance of manure in Indian agricultural systems is illustrated by extracts from various Reports, and the interdependence of water and manure is shown in the existence of the finest cultivation where both water and manure are available. Instances are given to show that the cultivator is not ignorant of the value of manure, but will, for certain crops, spend considerable sums of money upon it. The different sources of manurial supply are then examined, the ordinary cattle-manure being the most important, and, speaking generally, the only one available. Its composition is set out in analytical tables, and a comparison is instituted between it and ordinary farmyard manure, as met with in England, the result being to show that the value of Indian cattle-manure is often underrated, and that when it is burnt (as is so often the case) very serious loss is incurred. As the outcome of an enquiry in which I specially interested myself, I state the conclusion I came to, *viz.*, that the best cultivators do not burn cattle-manure for fuel except from necessity, that is, because they have nothing else to burn as fuel. The connection between the supply of firewood and that of manure is hence a very close one. Other sources of manurial supply are then dealt with in succession, *e.g.*, ashes of cattle-manure, sheep-folding, green-manuring, silt, soil-mixing, oil-seed refuse, nitre, lime, bones, &c., and various analyses of different materials so used are given in the Appendix. Special questions, such as the system of seed-bed cultivation known as *ráb*, the use and export of bones, and the likelihood of artificial manures being used in India, are treated in detail. Attention is then drawn to two points in which the cultivator does not take full advantage of the facilities he possesses (1) the non-utilization by him of night-soil for agricultural purposes; (2) the imperfect conservation of cattle-manure and the loss of the urine. In this connection instances are given of the highly beneficial results that have attended the use of night-soil, and analyses are given showing the value of cattle urine and the advantages to be gained by preserving it by the aid of litter. Incidentally, questions of town and village sanitation are touched upon, and throughout the chapter there are frequent references to investigations which could not be carried on without the aid of agricultural chemistry. In conclusion, it is maintained that water and manure constitute the cultivator's chief wants, and that the supply of manure must go hand in hand with that of water, and must, like the latter, be taken up by Government, otherwise the soil will not be able to provide for the increasing millions of the people. It is further held that, as cattle-manure is the only really available manurial source, it is incumbent on Government to provide supplies of firewood ("Fuel and Fodder Reserves") so that the cattle-manure need not be burnt, but may be set free for use on the land, and the fertility of the latter be thereby kept up.

Lastly, I set forth the duty of Agricultural Departments to make organised enquiry as to the manurial requirements of every district, to continue experimental research at Government Farms, and to spread agricultural education so as to teach better practices and remove prejudices.

RECOMMENDATIONS.

I recommend (1) the creation of supplies of fuel ("Fuel and Fodder Reserves"); (2) the establishment of a system of agricultural enquiry; (3) the spread of agricultural education; (4) the continuation of experimental work at Government Farms; (5) the employment of an agricultural chemist.

CHAPTER VIII.

CHAPTER VIII.

WOOD.

WOOD.

THIS chapter deals principally with the administration of the Forest Department and the extension of its work in a more agricultural direction than has been the case in the past. The early policy of the Department is first considered, and the reasons are given for its success having been gauged by financial results. But it is pointed out that, as population has increased and cultivation has been brought nearer to the borders of the forests, it has become necessary to extend the benefits of forests, so that they may more directly serve the interests of agriculture. In consequence of this, at the instance, first of Sir Dietrich Brandis, and then by successive representations of the Famine Commissioners and of the Government of India, a certain impulse has been given to the supply of wood for agricultural purposes. But it is urged in this chapter that there is a great deal more that ought to be done, and that the greatest need is that which was set out in the previous chapter, *viz.*, the supply of wood to take the place of cattle-manure as fuel. This is again put forward as a matter which Government should see to in their own interests, alike for the maintenance and increase of the soil's productiveness, as well as in order to keep up the Land Revenue of the country. The different classes of forests are then examined, and the uses which they might best serve are discussed, also the measures which should be taken to obtain those ends. Special points, such as the natural reproduction of timber trees, the guarding against forest fires, the exclusion of grazing, and the inadequacy of the forest staff, are alluded to separately. The wider adaptation of "reserved forests" situated near cultivation to the purposes of that cultivation is insisted on, and also the necessity of creating fresh supplies of wood. The difficulties of obtaining land for these new creations are admitted, but it is shown that there is still a quantity of land that could be so utilised, and suggestions are made for the acquirement of land, by purchase if necessary; the outlines of a scheme are also set forth for the working of the new "reserves" by a system of weight to proficiency in natural science. It is then suggested that junior Civilians, or at least a proportion of them, should, on arrival in India, be drafted into provincial Departments of Land Records and Agriculture, there to learn something about the country, the people, the crops, and the agricultural conditions generally, and that at their departmental examinations they should be required to show an acquaintance with these subjects. It is held that Directors of Agriculture should be chosen from the men who have shown a liking for natural science, and who have distinguished themselves subsequently by their knowledge of agricultural matters. The position of the Director of Agriculture is reviewed, and it is urged that it should be invested with some administrative power, and that the Director should form a part of the Revenue Administration. The giving to the Agricultural Department of a share in the administration of Government advances (*taccavi*) for well digging is again advocated. The necessity that Directors of Agriculture should tour in their districts is insisted upon, and is made applicable in a special way to the Secretary of the Imperial Department of Agriculture. The useful purposes which occasional Conferences on agricultural questions can serve are also exemplified. The classification of the work of Agricultural Departments is then referred to, and the main heads are briefly noted. Among them the importance of "analysis of districts" and the desirability of making a digest of the Land Records are put forward. Agricultural Shows are treated at some length, and suggestions are made for their improvement, as also for the better conduct of trials of implements.

In conclusion, the future policy of Agricultural Departments is discussed, and the two great needs—a competent organization, and the expenditure of more money upon agricultural improvement—are put prominently forward. Lastly, uniformity of purpose and continuity of policy in the work of Imperial and Provincial Agricultural Departments are strongly urged.

RECOMMENDATIONS.

I recommend (1) the giving of more weight to natural science in the open competitive and final examinations for the Civil Service; (2) the drafting of a certain proportion of junior Civilians into the Department of Land Records and Agriculture on their arrival in India; (3) the selection of Agricultural Directors from those who have distinguished themselves in natural science, and subsequently by their agricultural knowledge; (4) the giving of some administrative powers to Agricultural Directors, and, especially, that a share of the administration of Government advances (*taccavi*) be entrusted to Agricultural Departments; (5) the granting of more money to be expended by Agricultural Departments in the work of agricultural improvement.

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RECOMMENDATIONS

I conclude the chapter by recommending (1) the spread of General and Agricultural Education; (2) the establishment of an organised system of Agricultural Enquiry; (3) the active prosecution and encouragement of positive measures, such as the supply of water, wood, &c., which have already been found to be beneficial.

CHAPTER III.

CHAPTER III.

CULTIVATING CLASSES.

CULTIVATING CLASSES.

It is pointed out that certain "castes" and "races" of the people of India show more agricultural ability than others, and that the differences between them as cultivators are in great measure to be referred to the caste or race distinctions existing between them. It is very certain that if the prejudices attaching to caste and race could be broken down, considerable improvement in agriculture would result. Instances are next given which show indications of a change slowly going on. Thus, the prejudices against the cultivation of indigo and of the potato have, to a great extent, disappeared: also the cases of Nagpur, Poona and Amritsar are mentioned as showing that the prejudice against the use of night-soil as manure for crops is giving way. Improvement in coffee cultivation and in the manufacture of indigo, as the outcome of the example of English planters, is also distinctly traceable. The people, it is pointed out, will lose those caste prejudices which retard improvement in agriculture, partly through the spontaneous adoption by them of the more profitable practices, and partly from the force of circumstances which make living harder and oblige more attention to be paid to cultivation. In the weakening of caste prejudice Education is a most important factor, and Government by spreading it will help to break down the caste distinctions which prevent progress in agriculture.

RECOMMENDATION.

I therefore advocate the spread of General and Agricultural Education.

CHAPTER IV.

CLIMATE.

CHAPTER IV.

CLIMATE.

WITH the aid of the "Rainfall Map" included in the Report, the great variations of climatic conditions throughout India are illustrated, and their bearing is shown upon the crops grown, the agricultural systems pursued, the cattle, and even the people themselves. The close connection of famine with the rainfall is also set forth. It is pointed out that while it is to only a limited extent that climatic differences can be modified, yet that something can be done by increasing the means of irrigation in dry tracts, and by the creation of "reserves" of wood and fodder in districts where these are scarce. The influence of vegetation, and especially of trees, in improving climate is discussed; the real value consisting in the lowering of temperature, the production of a more gentle rainfall, the increase in the number of rainy days, the holding-up of the soil, the obtaining of a cooler earth-surface, and the retention of moisture by the soil.

It is maintained that such work must fall to the lot of Government, and that the people can be expected to do but little to aid it. Encouragement is, however, given to tree-planting by individuals, and this should be prosecuted more vigorously. It is further insisted that in order to get definite knowledge as to where provision of irrigation and "reserves" of wood and fodder can be made, careful enquiry must be set on foot by Agricultural Departments.

RECOMMENDATIONS

I recommend, accordingly, (1) the extension of irrigation to dry tracts; (2) the creation of "reserves" of wood and fodder (called "Fuel and Fodder Reserves"); (3) the planting of trees along canal banks and railway lines; (4) the further encouragement of Arboriculture; (5) organised enquiry by Agricultural Departments with the view of finding out where the foregoing measures can be adopted.

CHAPTER V.

SOIL.

CHAPTER V.

SOIL.

THE principal geological types of soil which occur in India are illustrated by the help of the "Geological Map" accompanying the Report, and the presence or absence of particular kinds of soil are indicated. The neglect, in the past, of any regular scientific study of Indian soils is referred to, and the important question is next dealt with—whether or not the soil of India is becoming exhausted under the present systems of cultivation. It is admitted that there is want of positive evidence in support of exhaustion, but instances are given from Settlement Reports and from the Famine Commission's Report, of a process of deterioration going on, and it is argued that under existing conditions of export of grain, oil-seeds, and manures, and the burning of cattle-dung for fuel, there must be a gradual deterioration of the soil. The wheat-yield of India is compared with that of other countries, and Sir James Caird's estimate of the crop-increase needed to provide against famine is alluded to, and the deduction is drawn that to supply this amount, not a *deterioration* but an *increased productiveness* of the soil is required, and that this can only be brought about by increasing the manure supply. The soils of India are then considered in respect of the different constituents which they contain, each ingredient being taken in turn. It is shown how important is the relation of water to soil, that organic matter (*humus*) and nitrogen are generally deficient in Indian soils, and that lime, potash and phosphoric acid are, as a rule, present in sufficiency. Several chemical questions of great importance are dealt with, such as the supply to plant life of nitrogen from atmospheric sources, the amount of nitrogen contained in the rainfall of India, the nature, occurrence and possible removal of saline deposits in soil, &c. The reclamation of land, whether it be ravine land, land infested with weeds, or land rendered sterile by the presence of salts (*usar* land), is dealt with, and instances are given of the various experiments which have been tried in different places. Throughout the chapter it is shown that the application of chemistry to the solution of the various agricultural problems connected with the soil is very necessary, and it is urged that future investigation should be pursued with its assistance.

In conclusion, it is pointed out that the work of soil improvement must devolve mainly upon Government, as in very few cases will the people have the means to take such measures in hand.

RECOMMENDATIONS.

I recommend in connection with the improvement of the soil,) the increase of the supply of water to dry tracts; (2) the crease of the manure supply; (3) the setting on foot of enquiry ascertain where such improvements are needed; (4) the continuation of experimental research aided by chemical science.

CHAPTER VI.

WATER.

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WATER.

It is indicated, at the outset, that while water in one form or another is indispensable in Indian agriculture, the amount and the method of supply will vary very greatly in different parts of India. In some parts rainfall is sufficient, in others artificial irrigation will be a necessity, in others, again, it may be a useful supplement. The nature of "protected" and "precarious" tracts is pointed out. The main types of water supply are summarised and then examined *in extenso*. Special points are noted, such as the benefits and the evils attending the introduction of canals, the comparison (where it is possible to make it) between cultivation by canal irrigation and by well irrigation, the differences in chemical composition between canal water and well water, &c. Embanking and drainage of land are spoken of, and instances are given of parts which stand in need of further irrigation. The great work done by Government in extending canals is favourably reviewed, and direction is turned to the necessity of Government undertaking all works of a major character, while minor ones may be carried out by the people. The possibility of Government constructing wells on a large scale is discussed, and improvements are suggested in the management of canal watercourses and tanks, and in the repair of the latter. The chapter goes on to treat fully of the system of advances known as *taccavi*, principally for purposes of well digging, and it is shown how greatly this is capable of further development, and of being made more popular and useful. It is maintained that the Agricultural Department should pay particular attention to this subject, and that a certain share of the administration should be vested in the Department. Suggestions are made as to improvements in the working of the system. Lastly, the necessity of a thorough "agricultural analysis" of each district of the country is insisted on with the view of ascertaining the local requirements in the way of water supply.

RECOMMENDATIONS.

I recommend (1) the further extension of canals and other means of irrigation to tracts where they are required; (2) the more energetic working and popularising of the system of *taccavi* advances for well digging and similar purposes; (3) the giving of a share in the administration of *taccavi* advances to Agricultural Departments; (4) the institution by Agricultural Departments of organised enquiry to ascertain the irrigation requirements of each district.

CHAPTER XVIII.

EXPERIMENTAL FARMS.

CHAPTER XVIII.

EXPERIMENTAL FARMS.

THE causes that have led in India, as well as in other countries, to the establishment of Experimental Farms as separate institutions are first described. The past work of such Farms in India is reviewed, and the expenditure upon them is regarded as not having been excessive, and their continuance is advocated. The chapter then proceeds to deal at length with the work which ought to be done at Experimental Farms, and to lay down the lines for the successful carrying out of experimental enquiry. The various conditions, such as suitability of soil, size of farm, situation, supervision, plan of experiment, recording of results, &c., are discussed, and are illustrated by examples drawn from existing Experimental Farms both in India and in England. It is then maintained that in the case of such Farms the financial test ought not to be the one that determines success. The employment of Experimental Farms as centres for seed distribution, the location of stud bulls, and, at times, for cattle-breeding, is recommended. The establishment of another class of Farms, *viz.*, Demonstration Farms, to show the result of what has experimentally been found useful, is advocated, and mention is made of farms belonging to private individuals where experiment is more or less carried on. The remainder of the chapter is occupied with a review of the work in progress at each of the Experimental Farms which I visited during my tour, my general comments on each Farm being given at the same time.

RECOMMENDATIONS.

I recommend (1) the continuance of agricultural enquiry at Experimental Farms; (2) the distribution of seed and the location of stud bulls at Experimental Farms; (3) the establishment of Demonstration Farms.

CHAPTER XIX.

AGRICULTURAL EDUCATION.

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AGRICULTURAL EDUCATION.

THE influence which general education first, and then, more specially, agricultural education, exert upon the improvement of agriculture is, at the opening, explained. It is then shown that the tendency of education in the past has been too much in a literary, and not sufficiently in an agricultural, direction. The suggestions now given are with the intention of remedying the past defect, and of directing attention to, rather than diverting it from, the cultivation of the land. The intention is, in brief, to give a more agricultural turn to education. The different grades of educational institutions, from Universities and Colleges down to Primary Schools, are then taken in order, and the line of agricultural education at each is briefly sketched out. As regards Universities, it is maintained that they should recognize the importance of agricultural science by making it an optional subject in the final course for a degree in science. It is not considered advisable, at present, to have special Agricultural Colleges, but rather to utilise existing institutions and to make agriculture one branch of the instruction provided. The importance of combining at Colleges practical work with theoretical instruction is set forth, and the establishment of Demonstration Farms, and of areas on which the students can themselves work, is advocated. Agricultural Classes in connection with High Schools are well spoken of, and the association with them of Illustration Farms is considered desirable. In Middle Schools it is held that the elements of physical science should be taught, that agriculture should be introduced by means of text-books, and that illustration *plots* rather than *farms* should be attached to the schools. In Primary Schools a beginning might be made by the introduction of "readers" and of "object lessons" on familiar agricultural topics. Lastly, the importance is inculcated of providing at Normal Schools sound training in agriculture for those who are to become the teachers of others. The paucity of text-books on agriculture, and the urgent need for many more of them, are commented on, the relation of the "scientific adviser" to agricultural education is discussed, and it is contended that more inducements to study agriculture should be given, and that the claims of men who have studied it should be freely recognized for appointments in the Revenue and cognate Departments. The chapter concludes with a brief review of the agricultural training given at different Colleges, Agricultural Classes, and other institutions which I visited, including the Forest School at Dehra Dun.

RECOMMENDATIONS.

I recommend (1) the spread of general education; (2) the extended introduction of agricultural education into the general educational system; (3) the preparation of agricultural text-books, suitable to the different parts of the country; (4) the recognition of the claims of passed students in agriculture to appointments in the Land Revenue and cognate Departments.

CHAPTER XX.

AGRICULTURAL DEPARTMENTS.

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AGRICULTURAL DEPARTMENTS.

The concluding chapter of the Report deals with some points in the working of Agricultural Departments, which have not already been fully treated. The first is the training of junior Civilians in agriculture. There commendations of the Famine Commissioners on this subject are discussed, and while it is maintained that it will be impossible to get civilian Directors of Agriculture who will at the same time be practised agriculturists, it is urged that much good may be done by giving at the open competitive and final examinations in England more

REPORT ON THE IMPROVEMENT OF INDIAN AGRICULTURE.

CHAPTER I.

HISTORICAL INTRODUCTION.

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HISTORICAL INTRODUCTION.

Early history of Agricultural Departments.

Lord Mayo's views, 1870.

First Agricultural Department. 1871.

Sir John Strachey and Provincial Department of North-West Provinces, 1875.

THE improvement of Indian Agriculture is a subject which in recent years has frequently been brought prominently before the notice of the Government of India and the Home Government. It was in 1866, on the conclusion of the work of the Bengal and Orissa Famine Commission, that the policy of having a special Department to watch over the interests of agriculture was first mooted. Lord Lawrence, however, thought the step premature. In 1870 Lord Mayo again took up the matter, chiefly in relation to the improvement of the supply of cotton from India, and in 1871 the first Agricultural Department was created. In Lord Mayo's opinion the work of the new Department was, "to take cognisance of all matters affecting the practical "improvement and development of the agricultural resources "of the country." Sir Richard Temple further pointed out that the success of a Central Department depended on the support given to it by similar Provincial Departments, the existence of which, under Local Governments, was implied. The only Provincial Government, however, which rendered any assistance was that of the North-West Provinces, where, in 1875, under Sir John Strachey, then Lieutenant Governor, the appointment of a Director of Agriculture and Commerce, to be at the head of a Department for collecting and arranging statistics of trade and agriculture, was sanctioned for a period of five years. Sir John Strachey also advocated the utilisation of Court of Wards' Estates for purposes of investigation, and the employment of them as "Model Farms," and for finding out the real condition of the cultivating classes.

Failure of Agricultural Department.

The causes.

2. As regards the Central Department, "though" (to quote the words of the Government of India's Resolution of December 1881) "under Lord Mayo's administration a "Department of Revenue, Agriculture, and Commerce was "created . . . . . the actual form departed widely from Lord Mayo's conception of its proper condition. Burdened with multiform duties the new Department had neither the leisure nor the power to take up either directly or efficiently 'the many problems which affect the agriculture and rural 'economy of the Empire." On its creation the new Department had handed over to it a number of miscellaneous subjects with which the three great divisions of the Administration, the Financial, Judicial, and Political, did not care to deal. So it came about that, with no definite programme of its own, and amid the varied subjects transferred to it, the new Department lost sight of Agricultural Reform. It was not Lord Mayo's intention that this should be so; but it was mainly from lack of provincial co-operation that his efforts were rendered futile, and in 1878 the Department was re-absorbed in the Home Department. The Secretary of State, nevertheless, expressed in a despatch the hope that this step would not interfere with Agricultural Improvement.

Abolition of Department, 1878.

Famine Commission's recommendations, 1880.

3. In 1880 the Famine Commissioners in their Report gave very strong recommendations as to the necessity of establishing Agricultural Departments under a Director in each Province. The duties were classed under three heads:—

(1.) Agricultural Enquiry—the collection of agricultural information to keep the authorities informed of the approach of famine.
(2.) Agricultural Improvement—with a view to the prevention of famine in future.
(3.) Famine Relief—to take charge of operations in the campaign against actual famine.

Imperial Department of Agriculture reconstituted, 1881.

Provincial Departments.

The Secretary of State himself added to the pressure brought to bear by the Famine Commissioners on the Government of India, and, as the outcome, an Imperial Department of Agriculture was formed in 1881 by again separating the Revenue and Agricultural Department from the Home Department. The several Local Governments agreed to this, and, accordingly, action was taken, and measures were commenced in 1882 for the formation of Provincial Departments of Agriculture.

Action taken by Government of India in carrying out recommendations of Famine Commission.

Land Record system.

4. It was, perhaps, on the first of the three heads named above that the Famine Commissioners laid most stress, and the Government of India, in accepting the obligations laid upon them, went still further, and, seeing that no special Department could take (as the Famine Commission had contemplated) the administration of famine relief out of the hands of local officials, turned primarily to the organisation of the Land Record system and the simplification of Settlement operations. Improvements were made in the village establishments which had been created under the Land Record system for compiling annually and collating the agricultural facts and statistics of every village in each Province; the Provincial Departments were made Departments of Land Records and Agriculture, and to them the maintenance of the above organisation was entrusted; also on them was put the duty of examining the Land Records and Village Maps, and from these and by means of local enquiry there was to be made an "agricultural analysis," which should indicate, not only the circumstances and conditions of each tract, but also the requirements of each, whether for protection against famine, or for the improvement of the agricultural system.

Government of India's Resolution, December 1881.

In the words of the Government of India's Resolution of 1881, "the Famine Commissioners have with great distinctness "intimated that, apart from any special organisation which "may be required to meet the exigencies of famine, or to "enter into any new field of agricultural experiments, a "permanent agency should be closely associated with the "existing authorities in each Province for the systematic "prosecution of agricultural *enquiry.* The importance of "this view, which directs attention to those duties of the "Agricultural Department which must precede any attempt "at agricultural *improvement,* has hitherto been far too "greatly overlooked." The Resolution further quotes the words of the Famine Commissioners, "the success of an "Agricultural Department would mainly depend on the "completeness and accuracy with which agricultural and "economic facts are collected in each village, and compiled "in each subdivision and district throughout the country," and it adds, "the Department would thus naturally acquire "that very knowledge which it has hitherto been the main "effort of a Settlement staff to attain. Without doubt, too, a "permanent Department of this kind would in course of time "become more competent to deal with questions of Settlement, "demanding, as they do, an intimate acquaintance with "agricultural conditions, than any temporary Department "forced to gain a hurried experience at great cost to the "country during the actual process of assessment." It was distinctly on the understanding that "Land Revenue "Organisation" was to form the first duty of the new Imperial Department that Mr. (now Sir Edward) Buck accepted office in August 1881 as its Secretary, in the belief that this work, though not so directly agricultural in character, would lay the foundation of all knowledge of the agricultural condition of the country, without which no attempt at "Agricultural Improvement" in the stricter sense could proceed. Meantime a Famine Code was drawn up, and Provincial Departments were gradually established. The work of "Land Revenue Organisation" was then proceeded with, and, when in June 1886 the Secretary of State asked for an enquiry into the expenditure of the new Departments, both Imperial and Provincial, it was found possible to prove satisfactorily to the Finance Commission of 1887 that, on purely financial grounds, and quite apart from any indirect benefit that might have accrued to agriculture, their establishment had been amply justified, and had resulted in the addition of a considerable increase of revenue to the State. Thus the importance of the Land Record system was confirmed, but a time of financial pressure having meanwhile set in, both the Revenue and Agricultural Department and the Finance Department shrank from giving anything like wide effect to the bolder recommendations of the Famine Commissioners which involved expenditure on direct agricultural improvement, although they were pressed by the Secretary of State to "institute measures for Agricultural

Famine Code.

Enquiry of Finance Commission, 1887.

Importance of Land Record system established.

" Research in India and the promotion of agricultural " knowledge in the Civil Service."

Application for Agricultural Chemist.

5. On one point, however, distinct representations had gone home to the Secretary of State, viz., the necessity of having a scientific ground-work as the basis of all attempts at agricultural improvement, and Chemistry being that science which bears, perhaps, most directly on Agriculture, the Secretary of State was asked as far back as 1882 to sanction the appointment of an Agricultural Chemist to act with the Department. It was pointed out, among other things, that there were large tracts of land, especially in the North-West Provinces, which were unculturable on account of the presence of noxious salts, and it was thought that science might aid in reclaiming these lands. There was also a further intention to utilise the Agricultural Chemist for educational purposes. The application has been repeatedly urged, viz., in 1882, 1884, 1886, and again in 1888 as the outcome of the Delhi Conference of that year.

Imperial Department of Agriculture ready in 1888 to take up recommendations of Famine Commission as to Agricultural Improvement.

6. In 1888 the Imperial Department having, in accordance with the Famine Commissioners' scheme (emphasised, as it was, by the Secretary of State), established Provincial Departments of Agriculture, having made provisions, by means of the Famine Code, against the difficulties of famine, and having, lastly, by the Land Record system, provided machinery for maintaining agricultural statistics for the administration of Land Revenue and the collection of agricultural information, they announced their work to be in a sufficiently advanced state to enable them to take up the remaining section of the Famine Commissioners' recommendations, viz., that referring to agricultural improvement. In connection with this the appointment of an Agricultural Chemist was once more urged. It was pointed out most clearly by the Government of India that the obligation imposed on them by the Secretary of State to give effect to the recommendations of the Famine Commissioners in relation to agricultural improvement still rested upon them, and that so long as they were not relieved from this obligation it remained in full force; further, that the other recommendations having been provided for and financial pressure having become less severe, they were now prepared to turn their attention to agricultural improvement. Still later (1889), the Home Department, by their Resolution on Technical Education, imposed upon both Agricultural and Educational Departments the further obligation to "take " positive measures for the education of the rural classes in " the direction of agriculture." Consequently the Agricultural Departments, Imperial and Provincial, have at the present time before them the positive duty of promoting both Agricultural Improvement and Agricultural Education.

Resolution of Home Department on Technical Education, 1889.

Obligation on Agricultural Departments to promote Agricultural Improvement and Agricultural Education.

Further application for Agricultural Chemist, July 1888.

7. The Delhi Conference, before-mentioned, had strongly represented the necessity of having at least one first-class

Agricultural Chemist for India, and had urged that the employment of such a man in connection with the expansion of the Forest School at Dehra, and with the College of Science at Poona, would be desirable for educational purposes, his time, when not engaged in the actual work of teaching, being devoted to agricultural enquiry. These views were endorsed in a despatch to the Secretary of State, dated July 21st, 1888. In reply, the Secretary of State, after seeking the opinions of the late Sir James Caird and Mr. Thiselton Dyer (opinions, it may be said, in several respects divergent, but agreeing as to the undesirability of making teaching a main point in the duties of such a man as might be chosen), expressed himself still unable to agree to the recommendation urged on him, and asked for further explanation. This the Government of India gave in their reply of June 1st, 1889, pointing out in detail the various classes of Natives for whom education in agriculture was desirable, and reiterating the necessity for systematic scientific enquiry in agriculture.

Reply of Secretary of State to application.

8. The Secretary of State, though not prepared without further investigation to accept these proposals, expressed his willingness to send out a competent Agricultural Chemist who should make enquiries in India itself, and (in the words of the despatch of November 7th, 1889) "advise upon the best "course to be adopted in order to apply the teachings of "Agricultural Chemistry to, and in order to effect improve-"ments in, Indian agriculture." The selection of an expert was entrusted to Sir James Caird, who himself had been one of the Famine Commissioners.

Sanction given to enquiry by expert, August 1889.

Sir James Caird did me the great honour of mentioning my name first, and, in preferring on behalf of the India Council the request to the Royal Agricultural Society of England for the use of my services, he expressed the hope that the Society, (of which he was himself one of the oldest members) would, in view of the importance and national character of the work, see their way to allowing me to undertake it, and to grant me the necessary leave of absence from my post as their Consulting Chemist.

Selection of myself by Sir James Caird.

Leave of absence granted by Royal Agricultural Society of England.

The Society, on their part, heartily granted the request made by Sir James Caird, and my delegation to India was ratified by the India Council.

Accordingly, on November 21st, 1889, I left London *en route* for Bombay, and arrived in India on December 10th.

Arrival in India December 10th, 1889.

9. The purposes of my deputation were thus defined by the Secretary of State:

Purposes of my mission.

To enquire into and advise upon—

1st.—The improvement of Indian Agriculture by scientific means.

2nd.—The improvement of Indian Agriculture generally.

My method of enquiry.

The method of enquiry I followed was, first to acquaint myself as far as I could, by travel, with the agricultural conditions of the country, as exemplified in selected tracts of a typical character; to visit all Experimental Stations and also the principal experiments conducted in the past by Government or by private individuals; to inspect educational institutions where agricultural teaching formed a part of the curriculum; and to obtain, by free discussion with officials and practical agriculturists, whatever information and suggestions I could as to the agricultural needs of the country. Taking one district specially, the Cawnpore district of the North-West Provinces, I visited it repeatedly, so as to follow systematically in one locality the progress of the various field crops at the different stages of their growth. Besides seeing the general agricultural crops, I enquired into the more special industries connected with coffee, tea, indigo, and jute growing, and into systems of Irrigation, of Grass Farms, and of Forest Administration.

My tours.

10. My travels were mainly divided into two tours—the first, from December 10th, 1889, when I arrived, until May 19th, 1890, when I reached Simla, my main object being to see the cultivation during the cold weather; the second, from July 14th until September 12th, which was occupied in seeing the agriculture of the country during the rainy season. In the interval spent at Simla between the tours, I had the opportunity of putting together the notes of my first tour, of consulting all officials connected with the Agricultural Department, and others interested in agriculture, and I also had free access to the records and library of the Department. I further drew up a brief summary of the conclusions I had arrived at up to that time, and these, under the name of "Preliminary Notes," were circulated privately, and were subsequently discussed at the Agricultural Conference held in October 1890 at Simla. On returning to Simla, after the conclusion of my second tour, I proceeded with the compilation of fresh information and the arrangement of the material I had already gathered for the purposes of my Report. The assembling of the Agricultural Conference at Simla, October 6th to 13th, after Sir Edward Buck's return from furlough, gave me the opportunity, of which I was glad to avail myself, of submitting my views to the consideration of the members composing the Conference, and of hearing their opinions and noting their suggestions. Leaving Simla in November, I made a short third tour before reaching Calcutta, and finally left India on January 10th, 1891, having been just thirteen months in the country. Thus, omitting Burma and Assam, which were not included within the scope of my enquiries, I was able altogether to visit each of the different Provinces twice, with the exception of the Punjab, viz., once in the cold weather and once in the rains. In the case of the Punjab the season had advanced too far to

Agricultural Conference at Simla, October 1890.

enable me to see the cold-weather crops, except just in the neighbourhood of Delhi.

Expression of special obligations.

11. The duty now devolves upon me of putting together my conclusions and suggestions, based upon what I was able, in the time at my disposal, to see of the agriculture of the country,. what I have gathered from the literature of the subject, and, above all, what I have gained from the experience of the many officials and others it has been my privilege to meet, and who have been always ready to assist me in every way possible. In the account of my tours I shall duly acknowledge the help that individuals have so kindly rendered me, but I must not pass on without mentioning some special obligations I owe.

Among the first I must name the late Sir James Caird, to whom I was indebted for my selection, and who gave me much advice derived from his own experience in India, and his acquaintance with its officials since; then Sir James Peile, of the India Council, and Sir Charles Bernard, of the India Office. Sir James Peile had charge in the Council of the matter of my delegation, and Sir Charles Bernard made the arrangements for my visit, and assisted me much by advice and suggestions, as also, after my return, in the issuing of my Report.

On the voyage out it was my good fortune to meet Mr. Robert H. Elliot, of Clifton Park, Kelso, well known both as a Scotch agriculturist and as a coffee planter in Mysore, and besides as an able writer on Indian agricultural matters. From him I learnt much that was afterwards invaluable to me.

In India, I must specially name Sir Edward Buck, Secretary of the Revenue and Agricultural Department of the Government of India, who took a deep personal interest in my mission, and provided for me every facility for making my investigation a complete and independent one. Sir Edward himself arranged for me an extended tour, and commended me everywhere to the officials of his Department throughout the country, so that I was able to see everything to the best advantage. Besides losing no opportunity of making me acquainted with the work of the Agricultural Department in the past, as well as with its objects and aims in the future, Sir Edward himself took me on my first tour to the North-West Provinces, and then on to Berar, Indore, and Bombay.

Next, I would express my indebtedness to the several gentlemen, mostly Directors of Provincial Departments of Land Records and Agriculture, who arranged tours for me in their respective Provinces, and who themselves personally conducted me throughout, providing in every way for my comfort, and ensuring that in the time at my disposal I should see, not only as much as possible, but also what it would be most advantageous to see. To them my sincere obligations are due, and I have ever-fresh recollections of much pleasant acquaintance with them, and of kindnesses received from them. These are :—

* Mr. J. B. Fuller (Central Provinces).
* Mr. E. C. Ozanne (Bombay).
* Mr. T. W. Holderness (North-West Provinces and Oudh).
* Mr. M. Finucane (Bengal).
* Mr. F. A. Robertson (Punjab).
Mr. C. Benson (Assistant Director, Department of Agriculture, Madras).
Mr. Muhammad Husain (Assistant Director, Department of Agriculture, North-West Provinces and Oudh).
Mr. H. C. Hill (Officiating Inspector General of Forests).
Mr. W. B. Wishart (Secretary, Upper India Chamber of Commerce, Cawnpore).

* Directors of Provincial Departments of Land Records and Agriculture.

I have further to express my thanks to His Excellency the Viceroy (Marquis of Lansdowne) for much personal kindness shown to me, and interest taken in my mission, as evinced in the several interviews graciously accorded me; to Their Excellencies Lords Reay, Harris, and Connemara, whose guest I have been at different times; and to the following Members of Council and Governors of Provinces for kind suggestions and advice: Sir Auckland Colvin, Sir James Lyall, Sir Steuart Bayley, Sir David Barbour, Sir Geo. Chesney, Sir Charles Elliott, Hon. Mr. (now Sir Philip) Hutchins, Messrs. Stokes (now Sir Henry Stokes), Garstin, and Clogstoun of Madras, and Mr. A. (now Sir Alexander) Mackenzie.

There are many other officials to whom my thanks are similarly due for much assistance rendered me in my enquiries, notably Colonel Forbes, Mr. Harvey James, General Badcock, Mr. W. C. Benett, Mr. P. Nolan, Mr. Justice Jardine, Mr. H. E. M. James, Colonel Ardagh, Mr. F. Henvey, Dr. Geo. King, Dr. Geo. Watt, Mr. J. E. O'Conor, Mr. Duthie, Colonel Pitcher, Colonel Marriott, Colonel F. Bailey, Major Clibborn, Mr. W. J. Wilson, Dr. Theodore Cooke, Major Elliott, Major Wingate, and the late Mr. S. A Hill.

Among the most pleasurable recollections of my tours will be those associated with the visits I paid to agriculturists, planters, and others to whom I was commended, and who everywhere showed me the greatest hospitality. It is impossible here to record the names of all, though they are well remembered by myself, but I must mention as representative,—Mr. R. H. Elliot of Mysore, Messrs. W. B. Hudson, J. J. Macleod, and T. M. Gibbon of Behar, Captain Chapman (Oudh), Captain Goad (Hapur), Messrs. Thomson and Mylne (Beheea), Mr. Macdonell (Serajgunge), Mr. G. W. Christisson (Darjeeling), Dr. Hendley (Jeypore), and, in the Punjab, Messrs. E. B. Francis, E. B. Steedman, J. A. Grant, H. C. Cookson, Captain Marrett, Major Massy, and Dr. Warburton.

Both at Calcutta and at Bombay I obtained from merchants much information which materially aided me in forming my conclusions. I would acknowledge here the kind help of Messrs. Octavius Steel & Co., Mackillican & Co., and Mr. Ross (Kelly & Co.) at Calcutta, and of the following firms at Bombay: Messrs. Volkhart Brothers; Finlay, Muir & Co.; Glade & Co.; Croft, Wells & Co.; and Mr. John Marshall of the Chamber of Commerce.

Lastly, I have pleasure in acknowledging the ready way in which the facilities of the office of the Revenue and Agricultural Department have been put at my disposal by Mr. Muir-Mackenzie, Mr. Tucker, and the other officials, also the great assistance I have derived from having had access to the records and library. To this Department I am further indebted for the preparation, by the Survey Office, of the three maps which accompany my Report, the Rainfall and Geological maps having been specially reduced from those in the "Statistical Atlas of India."

The present Report.

12. In one respect I have had an advantage over those whom I may term my "predecessors," in that a full year and exceptional opportunities have been given me. I believe, too, that short though the time at my disposal has been for the study of so large a subject as Indian Agriculture, my enquiry from a scientific point of view will have beneficial results.

It was my desire to avail myself, while still in the country, of the opportunity of gathering whatever information I could in order to supplement and to test my own observations; and so numerous were the matters brought under my notice during my travels, that, even with the extension of time granted me by the Government of India, and acceded to by the Royal Agricultural Society, I was unable to do justice to this large and important question of Agricultural Improvement. Rather than that I should be prevented from dealing adequately with it, I was very kindly allowed to present, on leaving India in January 1891, an Abstract Report, and to write the full Report subsequently, at my leisure.

CHAPTER II

CHAPTER II.

PRELIMINARY REMARKS ON THE POSSIBILITY OF IMPROVING INDIAN AGRICULTURE.

PRELIMINARY REMARKS ON THE POSSIBILITY OF IMPROVING INDIAN AGRICULTURE.

Danger of making "general" remarks on Indian agriculture.

13. It has been well said, and cannot be too often repeated, that "India is a country about which one cannot make a "'general' remark," and, certainly, with regard to Indian agriculture, this is strictly true; therefore, if I am asked whether the agriculture of India is capable of improvement, I must answer both "Yes" and "No." If, for instance, I am taken to see the cultivation of parts of Gujarât (Bombay), of Mâhim in the Thâna District of Bombay, the garden culture of Coimbatore in Madras, or that of Meerut in the North-West Provinces, and of Gújrat and Hoshiarpur in the Punjab, I may be inclined to say, "No; there is nothing, "or, at all events, very little, that can be bettered here;" but if, instead, I visit parts of Behar, the Dacca district of Eastern Bengal, the Central Provinces generally, Khândesh in Bombay, the Tanjore district of Madras, the Cawnpore district of the North-West, or Hissar and Multan in the Punjab, it will not be long before I may be able to indicate a field for improvement. Therefore, no general reply can be properly made to the question suggested; nevertheless, I do not hesitate to say that very frequently there *is* room for improvement, but it will have to be *looked for*, as a rule. Then, with the finding comes a yet harder problem, namely, to ascertain how improvement can be effected. If the deficiencies do not fall readily to hand, still less do the remedies, and I make bold to say that it is a much easier task to propose improvements in English agriculture than to make really valuable suggestions for that of India, such suggestions, I mean, as have a reasonable chance of being carried out. Altogether, the condition of the cultivating classes, the peculiar circumstances under which husbandry is carried on, the relations of the State to the people, and many other factors, have to be taken into careful consideration before one can give an opinion, and even that opinion must be given in very guarded terms. As India is not covered by *one* people, but by a number of different and diverse peoples, so may it be said of the agriculture and its systems as practised in different parts. That it not only needs, but will repay, close and careful study, I am convinced; and until systematic enquiry be made, not in the hurried way in which the exigencies of the case have obliged me to pursue my enquiries, but by patient watching and learning, no really sound knowledge will be obtained, nor any great improvement be intelligently inaugurated.

Complexity of the subject.

Erroneous opinions entertained in regard to Indian agriculture.

14. On one point there can be no question, viz., that the ideas generally entertained in England, and often given expression to even in India, that Indian agriculture is, as a whole, primitive and backward, and that little has been done to try and remedy it, are altogether erroneous. It is true, as indicated above, that no matter what statement may be made, as deduced from the agriculture of one part, it may be directly contradicted by a reference to the practice of another part, yet the conviction has forced itself upon me that, taking everything together, and more especially considering the conditions under which Indian crops are grown, they are wonderfully good. At his best the Indian *raiyat* or cultivator is quite as good as, and, in some respects, the superior of, the average British farmer, whilst at his worst it can only be said that this state is brought about largely by an absence of facilities for improvement which is probably unequalled in any other country, and that the *raiyat* will struggle on patiently and uncomplainingly in the face of difficulties in a way that no one else would.

Nor need our British farmers be surprised at what I say, for it must be remembered that the natives of India were cultivators of wheat centuries before we in England were. It is not likely, therefore, that their *practice* should be capable of much improvement. What does, however, prevent them from growing larger crops is the limited facilities to which they have access, such as the supply of water and manure. But, to take the ordinary acts of husbandry, nowhere would one find better instances of keeping land scrupulously clean from weeds, of ingenuity in device of water-raising appliances, of knowledge of soils and their capabilities, as well as of the exact time to sow and to reap, as one would in Indian agriculture, and this not at its best alone, but at its ordinary level. It is wonderful, too, how much is known of rotation, the system of "mixed crops," and of fallowing. Certain it is that I, at least, have never seen a more perfect picture of careful cultivation, combined with hard labour, perseverance, and fertility of resource, than I have seen at many of the halting places in my tour. Such are the gardens of Máhim, the fields of Nadiad (the centre of the "garden" of Gujarát, in Bombay), and many others.

But, to return to the question of improvement; while some have erred by calling the agriculture primitive, and, forgetting that novelty is not necessarily improvement, have thought that all that was needed was a better plough, a reaper, a threshing machine, or else artificial manures, to make the land yield as English soil does, others have equally erred by going to the opposite extreme, and have condemned all attempts at improvement, asserting that the *raiyat* knows his own business best, and that there is nothing to teach him. On one point, however, there can be but little doubt. The Native, though he may be slow in taking up an improvement, will not hesitate to adopt it if he is convinced that it constitutes a better plan, and one to his advantage.

15. Turning from these various opinions to those of the Famine Commission, it will be apparent that, as one result of

Opinion of Famine Commission.

their careful investigation, they came to the conclusion that there undoubtedly was capability of improvement, or they would not have so strongly insisted on measures being taken to effect it; they recognised, too, the necessity of careful and organised enquiry as a preliminary measure, and as necessary for acquiring a real knowledge of the agricultural state and conditions of the country. "The defect," says the Report (Part II., p. 138), "in the efforts made by Government to "instruct the cultivator has consisted in the failure to recog- "nise the fact that, in order to improve Indian agriculture, "it is necessary to be thoroughly acquainted with it, and to "learn what adaptation is needed to suit modern and more "scientific methods and maxims to the Indian staples and "climate." Here, however, came in the difficulty of effecting any remedy; and the section of the Commission's Report which deals with remedial action, though it indicates certain possible improvements, does not give any direct suggestion as to how they are to be carried out. The Government of India, as I have pointed out, when called on to give effect to the Famine Commissioners' recommendations, felt this same difficulty, and, having neither the machinery nor the means, put the matter aside until they could work out other reforms called for by the Famine Commission's Report. They have, however, never questioned the possibility of improvement in agriculture, and their action at the present time indicates this opinion strongly; what they have done is, to ask for the necessary machinery and the necessary money, and they have, as I think, wisely, determined that the work, if undertaken, shall be begun in a thoroughly scientific manner, and founded on a thoroughly scientific basis.

Opinion of Government of India.

Attitude of the enquirer.

16. I will not discuss here the opinions of the several "experts" who have preceded myself, leaving on record, as they have done, the conclusions drawn from the observations of their several tours. But I will give my own views, though well aware that I am adding one more to the list of opinions based on a more or less casual acquaintance with the agriculture, not of a country, but of a continent. The attitude one ought to adopt in coming to a land full of novel conditions is that of a learner, and not of the adviser or the critic; it is only when one has learnt something of the peculiar surroundings of his subject that he should attempt to suggest anything, and this he will, if wise, do very cautiously, feeling how very much there is for him still to learn, how much that he will never be able to learn. This is pre-eminently the case with Indian agriculture.

My opinions in the possibility of agricultural improvement.

Differences in agricultural conditions and practice throughout India.

17. My own investigations have brought very clearly to my notice what I have already alluded to in paragraph 13, viz., that there are very great differences in the agricultural conditions and practice that prevail in different parts of India, so that, while in some parts, as, *e.g.*, in Gujarát (Bombay), the agriculture is so good as to leave little room for improvement, in other parts, as, *e. g.*, in the Central Provinces, there is much scope for it.

My investigations have also shown me that there are great differences in the facilities that some cultivators have as compared with others, facilities, I mean, such as those for obtaining water, manure, wood, grazing, &c.

The first aim in any scheme of agricultural improvement should, I think, be to modify those differences which exist; first of all, by teaching, in the more backward parts of India, the better practices of the most advanced Indian agriculture; and, secondly, by supplying, wherever it is possible, those facilities which exist in the best agricultural districts. It is in the existence of these differences that there is a warrant for belief in the possibility of improving Indian agriculture, and it is in the modification of them that the greatest hope of improvement lies. Apart, therefore, from the question whether the agriculture of the country can be improved by the introduction of more scientific methods from the West, I believe the first step must proceed in the direction of improvement from *within*; in other words, by the modification of those differences in agricultural conditions and practice that exist in different parts of India itself.

Their existence the ground for possible improvement in agriculture.

I shall now proceed to enumerate these differences, and shall then show how, in my opinion, they may be most easily modified.

18. The differences appear to me to range themselves into three separate classes; and, after naming these, I shall proceed to briefly indicate, in a general way, the direction in which modification of differences, where possible, may be looked for. In subsequent chapters I shall deal with each subdivision separately.

Three classes of differences.

The three classes are :—

I. Differences *inherent to the people themselves* as cultivating classes—
for instance, the fact that, by hereditary practice, certain castes and races are bad, others are good, cultivators.

I. Differences inherent to the people themselves.

II. Differences *arising from purely external surroundings*, and not directly from any want of knowledge. These may be subdivided into—

II. Differences arising from purely external surroundings—

(*a*) physical causes—
such are :—climate, soil, facilities for water, manure, wood, grazing, &c.;

(*a*) physical causes.

(*b*) economical or political conditions—
such are :—the relative ease or difficulty of living, paucity or pressure of population, &c.

(*b*) economical or political conditions.

III. Differences *arising directly from want of knowledge*—
for instance, the existence of diversity of agricultural practice in different parts of the country.

III. Differences arising directly from want of knowledge.

Agencies by which improvement is to be effected.

19. Having stated the differences, it is desirable to consider in the next place the means by which they may be removed, or at least be modified.

This I can best put in the form of three propositions:—

- 1st. The modification of existing differences in agricultural practice and methods must proceed from positive measures taken—
  - (*a*) by the people themselves;
  - (*b*) by the Government.
- 2nd. So far as it is possible for Government or for Agricultural Departments to assist in the modifications of these differences, it is their duty to do so.
- 3rd. It is the work of Government to test Western practice and the applications of modern science, as also to introduce them when found suitable for India.

Illustrations of differences.

20. It will be well now to illustrate the foregoing differences, and, in indicating how their modification may be carried out, to give, at the same time, a sketch of the method I intend to adopt in the succeeding chapters of this Report.

I. Differences inherent to the people themselves.

I. Differences inherent to the People themselves:

It is well known that certain castes and races have been prevented by religious prejudices or "historical causes" (to use Sir Charles Elliott's expression) from adopting the more skilful or more laborious systems of cultivation in vogue among other castes or races. Thus, the Rájputs, Brahmans, Kolis, and Kols may be mentioned as hereditarily inferior as cultivators to the Játs, Kurmis, Lodhas, Káchhis, and others. Here it is not so much that the external surroundings are unequal, nor that the agricultural knowledge is at fault, but the real cause is found in the inherent differences of the people themselves. Side by side, in the same village, one may, for instance, see both superior and inferior husbandry, the explanation being found primarily in a reference to the respective caste of the cultivator in each case. In Behar I once saw a quantity of dung lying about in heaps on a field not spread out, but, between the rain and the sun, speedily losing its goodness. It had been lying about so for a considerable time. On asking a neighbouring cultivator why the owner did this, the reply was, "He is only a goatherd," meaning thereby that he did not belong to a good cultivating class. Here the people of this caste evidently required to be taught better methods of agriculture, and how to manage properly the manure at their disposal.

Their modification by the people themselves.

The modification of such differences (to revert to my propositions in paragraph 19) will, in some cases, be effected by the people themselves, in the gradual abandonment of their prejudices, and the adoption by them of more profitable practices. A change of this kind has been seen in the adoption of indigo cultivation by castes who formerly used to consider indigo an unclean thing. Another instance is the extension of cultivation of the potato, against which a religious prejudice existed on the ground that it was "flesh." The work that Government can do, and the duty that should be its, is to assist in raising the level of the people through the spread of Education. This will continue to do, as it has already done, a great deal to break down prejudice. Further than this the Government can do little, if anything.

Their modification by the Government through Education.

II. Differences arising from purely External Surroundings:

II. Differences arising from external surroundings—

(*a*) *Physical Causes.*—These may be subdivided into—

(*a*) physical causes.

(i.) climate and soil;
(ii.) facilities for water, manure, wood, grazing, &c.

(i.) These two—climate and soil—stand in a different category to the others. They are fixed by geographical and geological considerations; over them neither the people nor Government have more than a limited control, and consequently comparatively little can be done to modify the differences. For instance, it is not possible to compare agriculture under the influence of a damp climate and abundant rainfall, such as prevails in the greater part of Bengal, or below the Western Ghâts of Bombay, with that of the dry parched plains of Multan and elsewhere in the Punjab. Equally impossible is it to find a resemblance between the rich black cotton-soil of Berar or the Central Provinces, and the sandy soils of Sirsa, or other parts of the Punjab. The planting of trees may indirectly modify the rainfall, and plentiful manuring may improve the poorer soil, but they will be powerless to make the one locality or soil really like the other.

(i.) climate and soil. Modification of these differences only possible within limits.

(ii.) Here we have a set of physical causes giving rise to differences which, unlike those in the case of climate and soil, it is in the power, both of individuals and of Government, to mitigate to a considerable extent.

(ii.) facilities for water, manure, wood, grazing, &c.

Marked indeed are the differences between parts plentifully supplied by wells, or through which streams or canals flow, and those where these features are absent; so, again, the differences are great between treeless tracts and those in which forests abound, the latter giving alike shelter, grazing, and wood, besides causing a saving of manure to the land. Still, much has been done in the past, and more may yet be done, to mitigate the differences resulting from the existence of this class of physical causes.

Modification of these differences by the people.

The people in certain dry localities have dug wells, constructed tanks, and taken channels off streams.

On the other hand, in some parts, valuable land has been recovered by means of drainage, or by the construction of dams, made either by the people themselves, or by the Government through their engineers.

Modification by Government.

Encouragement has been given, and increased encouragement should be given, by Government to the extension of minor works such as the foregoing. Where, however, the effects are widespread, it is only by large measures, such as the State alone can carry out, that the mitigation of existing differences can be accomplished. Of such nature is the construction of canals by the State.

In the matter of wood and grazing supply, natural differences have, in many parts, been intensified through the reckless extermination of forests by the hand of man, or through excessive grazing with cattle and sheep, and more especially by goats. But, although the people are likely to do little to remedy, yet it is in the power of Government to save what is remaining. and to provide "reserves" for wood, fuel, and grazing, whereby, too, the supply of manure to the land may be saved.

Duty of Agricultural Departments in this connection.

It becomes, therefore, one of the most important duties of Agricultural Departments to ascertain and point out what measures are possible for the judicious modification, through Government agency, of differences resulting from such physical causes as the above named.

Need of enquiry.

This can only come as the result of close and careful enquiry as to what the needs of each locality are, and how they may be best supplied.

(b) Economical or political conditions.

(*b*) *Economical or Political Conditions.*—There are cases to be met with, *e.g.*, in parts of the Central Provinces, of Bengal, and of Madras, where, owing to the natural richness of the soil, the sparsity of population, or other causes, there is not the same struggle for existence as is felt elsewhere, and, as a consequence, the agriculture is often found to be inferior.

The lessening of these differences.

Here the change will only come with the inevitable disturbance which time and increasing population will cause in the easier circumstances under which the people in some parts live at present, as compared with those in others.

III. Differences arising directly from want of knowledge.

III. *Differences arising directly from want of Knowledge :*

There are many instances of the cultivation of one district being inferior to that of another, not on account of caste differences, nor yet on account of external and unfavourable physical surroundings, but simply because a better practice—I speak of Indian, not English, practice—has not been known. Or again, as I shall have cause to show, an implement is not in use in a district, though employed advantageously elsewhere, or cattle are poor because not properly fed, or manure is wasted (more especially the urine) because there is no litter to conserve it, or crops are inferior in yield because seed is not carefully selected.

Their modification by the State—
(*a*) by Education;
(*b*) by transference of agricultural methods.

The want of knowledge, and the lessening of the local differences arising therefrom, cannot be supplied directly by the people themselves, but they may be by the State, partly by means of Education, and partly by the introduction of better methods from localities where they are known, to those where they are unknown, but their application to which is both feasible and desirable.

Need of agricultural enquiry insisted on in Government of India's Resolution of December 1881.

This cannot be done without that "systematic "prosecution of agricultural *enquiry*" which is so strongly insisted on in the Government of India's Resolution of December 1881, and which, as is rightly urged, "must precede any attempt at "agricultural *improvement*."

Duty of Agricultural Departments to institute enquiry.

It is the positive duty of Agricultural Departments to acquire a thorough knowledge of, and acquaintance with, the agricultural facts of each Province with which they have to deal.

The agency required.

Such an enquiry, to anticipate my final recommendations, can, as the foregoing Resolution indicates, only be efficiently carried out by "a "permanent agency closely associated with the "existing authorities in each Province." Further, as I shall point out in subsequent chapters, I think that the assistance of an expert with special knowledge of the application of chemistry to agriculture is desirable in any such enquiry.

CONCLUSIONS.

CONCLUSIONS.

21. Owing to the great diversities met with in India, not alone in the physical features of the country, but also in the people themselves and in their varying surroundings, it is very difficult to speak generally of the condition of the agriculture. While in many parts it may undoubtedly be possible to effect improvement, it is not possible to do much, if anything, in others. Moreover, in every case it will be necessary to enquire carefully into existing conditions and practice before any real improvement can be carried out. That differences of conditions and practice do exist, constitutes, in my opinion, a ground of belief in the possibility of improvement, and it will be by the modification of these differences, and the transference of indigenous methods from one part of the country to another, rather than by the introduction of Western practice, that progress will be made and agriculture be bettered. This work will be done, (*a*) slowly by the people themselves, as they gradually come to see the necessity or the advantage of adopting the more profitable methods, (*b*) more quickly by the State, in the spread of Education, whereby prejudice will be broken down, and the benefit of better methods be made known. The introduction of such Western practices as may be found suitable to the case of Indian agriculture must also be the work of Government. Certain positive measures, such as the digging of wells by the people, the construction of tanks, &c., when found to be suitable, should be more persistently encouraged by the State, while major works, such as the making of canals, the provision of timber, fuel, and grazing, must be carried out by the State itself.

As a preliminary, however, to obtaining any real knowledge of the agricultural condition and needs of any district, there must be "a systematic prosecution of agricultural enquiry," such as is insisted on in the Government of India's Resolution of December 1881, and to this end there should be a permanent agency for the purpose in each Province. Lastly, I think that in any such enquiry the assistance of an expert with special knowledge of the application of chemistry to agriculture would be very desirable.

RECOMMENDATIONS.

RECOMMENDATIONS.

22. I recommend, therefore :—

The spread of General and Agricultural Education.

The establishment of an organised system of Agricultural Enquiry.

The active prosecution of positive measures already ascertained to be beneficial, and their further encouragement by the State.

I proceed now to consider, in reference to the subjects ndicated in paragraph 18, the agricultural conditions of the ountry as they have presented themselves to me, giving at he close of each section such suggestions for improvement as appear practicable.

CHAPTER III.

CULTIVATING CLASSES.

CHAPTER III.

CULTIVATING CLASSES.

23. As mentioned already, there are great differences between the various castes and races of India in respect of their cultivating abilities, differences which are inherent to the people themselves, and which are consequently difficult to level. Yet the very existence of these differences gives a decided encouragement to the belief in the possibility of improvement, for it would proceed on what, after all, are the right lines when dealing with Indian agriculture, viz., to improve it from within, and by means of its own examples, rather than by bringing foreign influences and methods to bear upon it. The fact that a cultivator in one place, or, better still, in the same village, can act as an example to another elsewhere or co-resident, may provide, if rightly followed up, a far more useful and less expensive practical proof of the possibility of improvement than a Government Experimental Farm. I remember being much struck by seeing, amidst the numerous wheat fields surrounding a village in the Central Provinces, a small holding of an acre or two, where, unlike elsewhere around, a well had been dug. The crops here were far more varied in character, sugar-cane and vegetables of many kinds were growing, and what water there was still to spare from these crops was being utilised for a wheat crop situated on the outskirts of the holding. I measured the standing corn, and found it to be then (February 23rd) 3 feet 8 inches high, whilst the wheat on unirrigated land adjoining was only 2 feet 1 inch high. On enquiry I found that the holding belonged to a man of the Káchhi caste; and when I expressed wonder that other cultivators did not follow his example, the answer given me was, that they were "wheat growers," and that it was not their "custom" to grow other crops. Although necessity had not yet obliged others to adopt an improved practice, there was an instance afforded here of what might be done if the necessity arose, the improvement having its origin in a purely native source.

Castes and races.

24. The subject of "caste" is one of much complexity, and demands, for understanding it, a very extensive knowledge of the country. I can, therefore, say but little about agriculture in its relation to, and as affected by, caste. As mentioned in paragraph 20, some castes are hereditarily inferior as cultivators to others, but the agricultural practice of any one caste is not uniformly alike everywhere, nor equally good. The Játs, for example, are spoken of in the Meerut district as being "unsurpassed as cultivators," but

Diversities in their agricultural practice.

in the Bareilly district they are not so good, and the Kurmis and Lodhas are superior to them there. The Rájputs and Brahmans do not themselves, as a rule, cultivate, but they employ hired labour; in some parts, however, they are described as being "moderate cultivators." Not only are there differences of caste, but there are also differences of race, as exemplified in the Kols (the aborigines of Chota Nagpur), the Bhils of Bombay, and others. Again, there are castes and races distinguished for the special branches of agriculture which they practise, or for the particular methods they employ; such are the Koeris, who are mostly growers of vegetables; the Kurmis, Lodhas, and Malis, who are largely market-gardeners; the Káchhis, who, in their cultivation, use the night-soil of villages and towns; the Vellola caste, again, are cattle breeders; the Gavlis are suppliers of milk, and also breed their own cattle; the Gujars, Vanjaris, and others are graziers.

Method pursued in this chapter.

25. Bearing in mind the method set forth in the last chapter, I shall confine myself to considering how far improvement in agriculture may be effected through the lessening of those differences which are directly due to caste or race prejudices. The further question of the improvement of the cultivation of one locality by the importation into it of the practice of another, is one not directly connected with the inherent differences of cultivating classes as such, and will be dealt with elsewhere.

Breaking down of caste prejudice would be followed by improvement in agriculture.

26. That the breaking down of caste prejudice would be followed by considerable improvement in agriculture admits of no doubt, and needs but little discussion. Could the Rájput or Brahman be brought to see that there was nothing derogatory in manual labour, or in taking an interest in the cultivation of the soil; could other cultivators be led to follow the practice of the Káchhis, and abandon their prejudices against the use of night-soil as a manure; they could then raise crops such as the Káchhi does, and the country would be greatly benefited thereby.

In the course of my first tour Sir Edward Buck pointed out to me a village, named Singhouli, in the Doab, where the former tenants, who happened to belong to a low caste (Kurmi), had worked so industriously and profitably that they had actually been able to buy out the original proprietors who were of higher caste (Rájput), and had become possessors of the village themselves.

The town of Farukhabad, again, is surrounded by a perfect garden, the result entirely of Káchhi cultivation. When, about twenty years ago, Sir Edward Buck transferred some of these cultivators from Farukhabad to Cawnpore, they showed at the latter city how a profitable use could be made of what would otherwise have been a public nuisance, and also how the State revenue derived from the area they cultivated could be very largely increased.

How breaking down of prejudice may be brought about—

(*a*) by the people themselves;

(*b*) by the force of circumstances.

27. The breaking down of caste prejudice in agricultural matters may proceed slowly from the people themselves in the gradual abandonment of inferior practices in favour of more profitable ones; but it will be brought about more rapidly by the force and exigencies of circumstances which call for greater attention being paid to the cultivation of the land. Already there are indications of a change going on. It has been mentioned that indigo cultivation is now carried on by castes who used formerly to consider indigo an unclean thing, and that the prejudice against the potato and its raising has now also largely disappeared.

Indications of a change going on.

Some eight or ten years ago a batch of Káchhis from the North-West was transferred to Nagpur, in the Central Provinces. Not only did they continue to employ their particular practice with profit, but other cultivators around followed their example, amongst these being even Brahmans. The latter began to grow sugar-cane and vegetables of all kinds, just as the Káchhis had done. Their cultivation is still inferior to that of the Káchhis, but, nevertheless, a beginning has been made in the way of improvement, and this has originated entirely from the example set by the Káchhis. I might instance, too, the sugar-cane cultivation around Poona. This was commenced by a Brahman who first showed the Municipality how to make "poudrette" out of the night-soil of the town, and then taught the Hindu cultivators how to use it. The "poudrette" is now used to an enormous extent. At Nagpur, again, I saw Brahman lads engaged in cultivating; they work with the plough just like the other pupils of Mr. Fuller's Agricultural Class; indeed, Mr. Fuller makes it a *sine quâ non* that they should do so.

In the Kapurthala Administration Report for 1890, page 31, Major Massy writes: "The Rájput is proud, idle, and not "thrifty . . . . but still is a better cultivator than his fore-"fathers were; he goes out to his fields more regularly, and "begins to realise that he must earn his living by the sweat "of his brow." In the Hoshiarpur Settlement Report it is stated that some of the Brahmans and Rájputs will now plough their lands with their own hands.

Thus it is clear that a change is going on.

Progress of improvement.

28. The work of improvement by example may be, and probably will be, a slow one, and where circumstances (as in the case I have cited from the Central Provinces) do not call for the positive necessity of arousing themselves to better their agriculture, the higher castes or the more easy-going cultivators may hold to their old ways; still, there is undeniably a tendency, wherever pressure has begun to be felt, for the inferior cultivating classes to adopt the practice of the superior and more thrifty ones. When once a change of this kind has set in, its progress is, as a rule, rapid. I need but instance the case of Amritsar, where, though but a short time has elapsed since their introduction, vegetable-growing and market-gardening are now carried on most extensively, and almost entirely by the utilisation of the night-soil of Amritsar as manure, in conjunction with canal irrigation. It would, not long ago, have been considered impossible for this to happen, or for night-soil ever to be turned to a profitable use, on account of the prejudices of the people against it. These prejudices still exist in many places, but I am convinced that they must give way, as they have done already, especially when the necessity of increasing the yield of the land is forcibly brought home.

Improvement by force of example is not confined to native methods only, for, as Mr. R. H. Elliot pointed out to me, coffee-planting by the Natives has improved very considerably in Mysore since European planters settled in the country and introduced better systems. The same remark applies to the cultivation and manufacture of indigo since English planters came to the districts where the plant is grown.

The influence of Education.

29. While the remedy for inferior cultivation will be found largely in the exigencies of circumstances which demand more attention being paid to the land, it is in the weakening of those caste prejudices which account, in no small measure, for the differences between good and bad cultivators, that Education plays a most important part. Already its influence has been felt. I have noticed above, the case of the Nagpur Agricultural Class, and I might say the same in regard to the Poona College of Science and other institutions which I have visited. The spread of Education will be one of the most potent factors in creating that interest which agriculture, from its widespread extension and importance as the staple industry of the country, both merits and demands.

The work of Government.

It is, therefore, through Education that Government can aid largely in lessening those differences which are at present inherent to the cultivating classes as such, and which stand in the way of agricultural improvement.

CONCLUSIONS.

CONCLUSIONS.

30. Improvement in agriculture, through the modification of differences due to caste and race prejudice, may be effected by the gradual breaking down of that prejudice. This will result partly through the people themselves, in their adoption of more profitable practices, partly from the force of circumstances obliging greater attention to be paid to the cultivation of the land.

Government can greatly aid, through the spread of Education, in weakening caste prejudice.

RECOMMENDATION.

RECOMMENDATION.

31. My suggestions under this head accordingly resolve themselves into—

The desirability of extending General and Agricultural Education.

CHAPTER IV.

CLIMATE.

CHAPTER IV.

CLIMATE.

32. THIS all-important factor in Indian agriculture is, unfortunately, one that can only be altered or modified to a limited extent. Interesting, therefore, as a study of the influence of climate on agriculture may be, we should, nevertheless, be dealing with one of those elements which the cultivator finds *in limine*, and in accordance with, and not in opposition to which he must frame his practice, because neither his energy nor the help of the State can to any great extent modify its conditions. It will, therefore, not be necessary for me to go deeply into this part of the subject beyond touching on a few striking instances of the effect produced on the practice of agriculture by differences of climate.

Effects produced by climate on the crop-seasons.

33. As explained in the "Statistical Atlas of India," it may be said that over the greater part of India there are three well-marked seasons, viz., the rainy season (June to October, inclusive), the cold season (November to February, inclusive), and the hot season (March to May, inclusive). The two former are due, respectively, to the prevalence of the south-west and the north-east monsoons, whilst the hot season marks the transition from the cold to the rainy season. Yet these alone do not determine the kinds of crops grown, and we do not find in all parts alike that there are crops corresponding to the different seasons. The relative dryness or dampness of the climate has also to be considered. Through the kindness of the Revenue and Agricultural Department of the Government of India I have been supplied with copies of maps illustrating the Rainfall and Geology of India; these have been specially reduced, by the Survey Department, from the corresponding maps in the "Statistical Atlas of India," and accompany the present Report. A reference to the Rainfall Map will here help to explain the remarks which follow. The contrast between climates is more marked in Northern than in Southern India. In Southern India, generally, it may be said that there is uniform warmth, with dampness towards the west and dryness in the east and interior; but in Northern India we find every variation, from the dry climate of the West and North-West, accompanied by marked differences of summer heat and winter cold, to the permanently damp climate and heavy rainfall of Assam and Eastern Bengal, where the differences of temperature are not so extreme. So it comes about that, whilst in the North-West and Northern India generally there are two clearly defined crop-seasons, viz., the rainy season (*kharif*) and the cold season (*rabi*), we find that in Madras these distinctions disappear, and we have only early and late sowings of the same crops. In Behar and some other parts of Bengal there are three rather than two seasons, with their attending crops, viz., the early rainy season (*bhadoi*), the late rainy season (*aghani*), and the cold season (*rabi*).

Great variation in rainfall of different parts, as shown in "Statistical Atlas of India."

Relation of rainfall to famines.

"Protected" and "precarious" tracts

34. The Report of the Famine Commission abounds with instances proving that famines are the result of one cause alone, viz., failure of rainfall. A reference here to the Rainfall Map will show how very varied is the distribution of rain over the country. In Burma, Assam, Eastern Bengal, and along the coasts of the Western Ghâts there is abundant rain; also a rain tract exists along the foot of the Himalayas. In the Central Provinces, too, there is a plentiful rainfall. It is these parts, therefore, which are the most free from famine. So, again, but for a quite different reason, are the very driest regions of all, parts of the Punjab, for example, since there the *raiyats* will never try to grow a crop or to cultivate unless there is a certainty of water supply. The most precarious tracts are those where the chance that enough rain may come gives a temptation to venture on growing a crop, and then, if drought intervenes, there is a total failure of harvest. These are the parts which are light-coloured on the Rainfall Map.

Illustrations of the effects produced by climate on the practice of agriculture in different parts.

35. The dependence of certain crops on heavy rainfall and a damp climate is well marked in the case of tea culture in Assam, where the annual rainfall is from 90 to 160 inches or more, and in that of indigo in Behar, or of rice in Bengal and on the Western Coast of Bombay. Other crops, such as gram (*Cicer arietinum*) and *arhar* (*Cajanus indicus*), can, on the contrary, do with a minimum of moisture, and flourish in a hot dry climate, such as that of the North-West. Whilst the damp climate of Behar and Bengal favours the growth of the indigo plant but not the ripening of the seed, the hotter and drier climate of the North-West Provinces or the Punjab causes the seed to yield well there, and the two cultivations are, for the most part, carried on in separate Provinces. With wheat-growing we have marked contrasts of climatic surroundings, as shown, on the one hand, in the case of the plains of the Punjab and North-West Provinces, and on the other, in the wheat districts of the Central Provinces. In the former, dependence is placed largely upon irrigation, for the soil soon loses its moisture and becomes baked; indeed, one may sometimes see (as I myself saw) a wheat crop on which not a drop of rain had fallen from time of sowing to harvest, so that, were it not for irrigation, famine might be ever at hand. In the Central Provinces, on the contrary, an abundant and regular rainfall, and a soil which retains that moisture firmly, make famine nearly impossible and do away with the necessity of irrigation. In the Central Provinces, further, alternation of rainy-season (*kharif*) and cold-season (*rabi* crops is not so common as in Upper India. The soils are of more marked diversity, and are better suited, some for rainy-season, others for cold-weather crops.

Going southwards, as I did in my second tour, from Delhi, through Rájputana, and down the western side of the Bombay Presidency, along the north of Madras, then to Bengal, and returning finally to the Punjab, I had abundant opportunities of seeing how systems of agriculture must be varied according to the climate. Passing from the hot plains of Rájputana, with its sparse cultivation and low rainfall, one comes to districts of heavier rainfall, say 60 to 90 inches, such as Baroda, Nadiad, and Máhim, where rice will grow without irrigation, the rainfall alone sufficing; at Kalyan and Igátpuri (nearer Bombay) the rainfall varies from 100 to as much as 150 and 170 inches annually, and the *ráb* * system of making the rice seed-bed is in vogue, whilst it is not employed in districts of lighter rainfall. Grass headlands and live hedges are also features of many of these parts. If, however, we go inland to the Khándesh (Deccan) district, we find a rainfall of but 30 inches and the crops quite different, rice being replaced by cotton and millets principally, wheat also coming in. On the southern side of the Bombay Presidency districts are successively passed in the journey by rail which have an increasing rainfall, from the Kistna Valley, where it is 40 inches, to Belgaum with 65 to 80 inches, while only another 20 miles or so further on it is as much as 150 inches annually. In each district the cultivation is different, rainy-season crops being distinctive of the first named, except where patches of black soil interspersed among the other (which is mainly red) enable moisture to be retained for growing cold-season crops, such as wheat and gram. In Belgaum, as also in Dhárwar, the exceptional feature of hot-weather rains in May allows of the early sowing of rice, for the heavy rains later on can always be depended upon; but *ráb** is not practised, whilst in the extremely rainy and unhealthy region nearer the Western Ghâts it is. On the red soil of Dhárwar, with a rainfall of about 45 inches, rice is, as mentioned, grown early, but on the black soil nearly all the cultivation is that of dry crops. Going on into the Madras Presidency, we find fresh factors regulating the crops that are grown, for not the south-west monsoon alone, but also the north-east monsoon plays an important part, and when the former fails, the cultivators wait for the second, and have thus a double opportunity of sowing. Again, in Madras there are not the wide divergencies of temperature that occur elsewhere, but a more regular and continuous warmth exists throughout the year, and so it may be said that the crops, to a considerable extent, go on independently of season. To pass from such conditions as these to those of the damp and hot climate of Bengal, with its rice and jute and indigo growing, and then back again to the Punjab, implies seeing very great changes indeed in the agriculture. Even in the last-named Province, with variations of annual rainfall from the 7 inches found in the arid tracts of Multan and the 14 inches in Hissar, to the 26 inches of Amritsar, or the 35 inches of Hoshiarpur, the surroundings of agriculture must affect its practice vastly. In the first-named district canals are absolutely necessary for the purpose of cultivation; in the last-named the water-level is quite near the surface of the ground. In yet other parts, such as Hissar, where there is great want of water, and not sufficient for the sowing of winter crops, nearly all the crops are rainy-season ones.

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* *Ráb* system.—Alternate layers of cow-dung, loppings and leaves of trees, grass, and earth are heaped up on the ground which is to form the seed-bed, and the whole is then set fire to, and the ashes mingled with the soil.

It is remarkable, too, how within quite a limited area the rainfall will vary. The following instance has been given me by Mr. J. J. Macleod: at Segowlie, in Behar, it is 80 inches yearly; at Rájghat, 9 miles to the west, 47 inches; at Beyreah, 5 miles west of Rájghat, 36 inches; and at Mallyah, 5 miles south-west of Beyreah, 26 inches; whilst at Dhodkrahar, 6 miles north of Segowlie, it is 66½ inches.

Effects produced by climate on the cattle and people.

36. But it is not in the crops alone that the influence of climate is seen; it is exemplified strongly in the case of the cattle, and even in the people themselves. It is only necessary to mention one single illustration out of many, viz., the wide difference between the diminutive bullocks and cows of Bengal, where a damp hot atmosphere prevails, and the fine, large, strong cattle of Hissar and other dry parts of the Punjab. In the latter Province the atmosphere, though hot, is clear and dry, and the soil is far more adapted to the breeding of cattle than are the damp regions of Bengal. We see, however, the reverse in the case of buffaloes, as no climate seems too damp or rainfall too heavy for them. Thus, at Máhim (Thána district of Bombay) the buffaloes are magnificent, but the other cattle are poor and miserable; so, too, is it in Eastern Bengal; in Behar, where it is drier, the plough cattle are again superior. Buffaloes are the principal plough cattle throughout the districts of heavy rainfall below the Western Ghâts; here the preparation of the rice fields, covered as they are with water to the depth of several inches, could only be carried on by means of buffaloes. In the Punjab fine buffaloes may be seen, it is true, but it is as a milk-giver that the animal is esteemed there, and its excellence depends upon the practice there in vogue, of growing fodder-crops for the cattle, and of driving the buffaloes to the forests or to the river banks to remain there during the hottest months of the year.

What is true of the cattle in respect of diversity produced by climate is true also of the people. The inhabitants of the dry, and at times cold, Provinces of North-Western India are far stronger and more active than those of the always damp and warm Provinces such as Bengal, although in these latter the people are the more mentally acute. Their respective foods have undoubtedly also to do with these differences, but the foods themselves must be considered as determined by climate, for it is alone in the cooler and drier climate that wheat will flourish, while rice rejoices in a damp warm climate such as that of Bengal.

Elimination of differences resulting from climate impossible.

37. I said at the opening of this chapter that climate is one of the external circumstances influencing agriculture, in which changes can only be effected to a limited extent. It is impossible, therefore, to eliminate the differences that result from it; the most that can be done is to mitigate their influence. In two directions, possibly, there is some hope of doing this :—

Mitigation of the differences—

(*a*) by irrigation;

Firstly,—by the supply of Canals and other means of Irrigation to the drier tracts of the country;

(*b*) by preservation of forests and creation of "reserves" of wood and fodder.

Secondly,—by the preservation of Forests and the creation of "reserves" of Wood and Fodder.

To such supplies as the last-mentioned the name of "Fuel and "Fodder Reserves" is generally given, and will be used throughout this Report.

Beneficial influence of trees.

38. The beneficial influence of irrigation in dry tracts is obvious, but that resulting from the growing of trees needs some explanation.

It has been much debated whether forests and plantations do actually bring about an increase of rainfall or not. But I would point out that their real influence and value consist in their *lowering the temperature,* and thus causing moisture to be deposited where otherwise it would pass on. As a consequence of this, forests and plantations will cause rain to fall in gentle showers instead of in heavy and often destructive deluges. Thus, a given quantity of rain will be distributed over a greater number of days, and its value to the agriculturist will be thereby largely increased. The true test of the value of afforestation in this connection is, not so much whether the *total* rainfall be increased, but whether the *number of rainy days* be more. The dewfall is also increased in the neighbourhood of trees, and this has considerable agricultural importance, too.

It has not unfrequently been observed that in times of drought there has been plenty of rain in the clouds overhead; what was wanted was some agent to condense and "bring it "down." Trees would materially assist in performing this. Again, the difference between the action of a gentle rain and that of a heavy deluge is very marked; for, while in the former case the water sinks gradually into the soil, in the latter it rapidly runs off the baked surface of the earth, and very often causes much damage by the destruction of roads, the washing away of bridges, and the silting-up of tanks.

Increase of rainfall in Neilgherries through tree-planting.

Through the kindness of Mr. Robert H. Elliot of Mysore, I am able to supply a practical illustration of the value of woods, and one which would show that, in regard to rainfall, a climate can be favourably influenced in about 25 years.

Mr. Elliot, when in the Neilgherries in 1891, carefully examined, with the aid of Government officials, the Rain Records from 1870 to 1890. Previous to 1870 Ootacamund and its neighbourhood were nearly bare of trees, so much so that a photograph taken about that time has no resemblance whatever to the now thickly-wooded Station, the result of a large amount of planting, both by Government and by private individuals. The returns show that, taking first the rainfall for the months of March, April, and May (when the rains are purely local), there were, during the five years 1870–4, 121 rainy days in all, while in the same months of the five years 1886–90 (by which time the Station had become fully wooded) there were no less than 147 rainy days. Also, the increase of rainfall for these months during the period 1886–90 has been about three inches a year, a not inconsiderable difference, though, from an agricultural point of view, the distribution of rain over a greater number of days is more important than a mere increase of rainfall. Again, taking all the months of the year except June, July, and August (which are excluded because the rains of this period are not local in origin, but are those of the south-west monsoon and come from a distance), it was found that during the treeless period 1870–4 there was a total of 374 rainy days only, whilst during the wooded period 1886–90 there were 416 rainy days. Further than this, it was ascertained that the character of the rainfall had altered within late years, light and regular rain showers taking, to a great extent, the place of destructive occasional torrents. The agricultural importance of these facts is very great indeed.

Other benefits attending tree-planting.

But there are other indirect benefits attending the spread of tree-planting, benefits affecting the soil itself more particularly. What trees do is to hold up the soil, preventing it from being washed away and carried off by streamlets; next, a coating of vegetation soon covers the soil on which trees are growing, and binds it together, though at the same time rendering it permeable to and retentive of moisture, so that the rain no longer flows off as it would over a hard dry surface without benefiting the soil below. Thus, a cool surface is produced in place of an otherwise dry and heated one on which the sun's rays would impinge directly, and from which they would be reflected; shade and shelter are provided, and in the end a moister climate will prevail. From old records and descriptions of India there is reason to believe that the climate was not formerly what it now is, but that the spread of cultivation, accompanied, as it has been, by the wholesale and reckless denudation of forests and wooded tracts, without reservation of land to afford wood or grazing, has done much to render the climate what it now is. Sir

William Denison states that, when Governor of Madras, he was shown districts in which the rain had retreated as the forests had been cleared back, and he points out that when a rain-carrying cloud comes in contact with the bare and heated soil the tendency is for the moisture to be held up in suspension in the air, and not to be deposited on the earth. Such districts were found in Cuddapah, Madura, and Travancore.

Instances.

1. Madras.

2. Cairo.

The case of Cairo has been instanced in support of the view taken as to the beneficial effect of trees; since plantations have been established there a rainfall has appeared, whilst before this there was none. It is impossible, however, to say how far this result is due to the planting of trees, and how far to the opening of the Suez Canal, which latter is known to have caused distinct climatic changes.

3. Etawah.

When visiting Etawah (North-West Provinces) I went to see a plantation for the supply of wood and grass; this had been established about five years previously on land which was nothing more than bare ravine land. The whole extent of the plantation was 7,000 *bighas* (4,375 acres). I was assured that the Station had not been so hot since the plantation had been formed, and, anyhow, it is very certain that the now wooded and grass-covered ravines are very much cooler than the former bare open spaces were. At Jhansi I was told the same thing, and that since the introduction of the system of *bunding** the streams and planting the slopes with trees, the Station had been cooler.

I am reminded here of an old Sanskrit saying which describes the rainfall as being divided into twelve parts, and assigns them as follows: "Six for the sea, Four for the "forest and mountains, and Two for the land."

Work of Forest Department in this connection.

39. Though immense tracts of country have been denuded in the past, there are still considerable areas which can be taken up and rendered serviceable for climatic ends, and the Forest Department has stepped in none too early in the endeavour to save those wooded tracts which are still left. From climatic considerations alone, the work of the Forest Department is, accordingly, of importance.

Other measures for supply of shade and shelter.

40. In addition to the protection of forests, and the reservation of considerable tracts for the creation of "Fuel and "Fodder Reserves," there are other minor measures which have often been urged by the Imperial Department of Agriculture, and which, while primarily supplying timber and fuel, also exercise a benefit in the provision of shelter, shade, and coolness in the immediate vicinity. Such are the growing of trees along canal banks and railway lines, and the encouragement of Arboriculture by the planting of trees along the sides of roads.

Plantations.

Arboriculture.

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* *Bunding.*—Embanking, *i.e.*, holding up the streams that would flow over the land during heavy rain, by means of embankments on which grass is allowed to grow, and on which trees are sometimes planted as well.

These matters will be more fully dealt with in Chapter VIII. when considering the wood supply of the country.

The application of remedial measures must be undertaken by Government.

41. But little help must be expected to come from the people directly, in the attempt to mitigate as far as possible the influence of climate. They are hardly likely to originate such measures as have been suggested, and they have not the means to carry them out. Too often, it is to be feared, they will even oppose the taking of remedial action, at all events at the outset. Such has been the case already with Forest preservation, and it will not be until they are convinced of the utility of the measures taken for their benefit, and for the improvement of their agriculture, that the people will accord their hearty support; the tendency with them will be, as it has been in the past, to clear and to destroy rather than to save and to plant. Something may be done by way of encouragement in offering rewards for tree-planting, but it is clear that the work, both of irrigation schemes and of maintenance and creation of wood "reserves," must fall to the share of Government.

Duty of Agricultural Departments to enquire where remedial action should be taken.

It becomes, therefore, the duty of Agricultural Departments, first, to make a careful enquiry as to the localities in which measures for mitigating the severity of the climate are most needed; then, to ascertain what the nature of such action is to be, and how it may be best applied. This can only be done efficiently by instituting an enquiry such as that I have drawn attention to in Chapter II., and by an "agricultural "analysis" such as is sketched out in the Government of India's Resolution of December 1881 (*see* paragraph 4 of the present Report).

CONCLUSIONS.

CONCLUSIONS.

42. While the elimination of differences due to climate and affecting agriculture cannot be achieved, the mitigation of their influence is to some extent possible. This may be done by increasing the means of irrigation to dry tracts, and by preserving and extending "reserves" of wood and fodder. In these ways an improvement in agriculture may be brought about. Both measures are the work of Government.

RECOMMENDATIONS.

RECOMMENDATIONS.

43. I recommend:—

The extension of Canals and other means of Irrigation to the drier tracts.

The establishment, wherever possible, of "Fuel and Fodder Reserves."

The increase of Plantations along Canal banks and Railway lines.

The spread of Arboriculture.

The instituting of Enquiry by Agricultural Departments as to where the above measures are needed, and how they may best be carried out.

CHAPTER V.

SOIL.

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SOIL.

Absence of scientific study of the soils of India.

Need of caution in applying results of scientific enquiry to Indian agriculture.

The real use of chemical analysis of soils, &c.

44. THE soils of India have not, so far, been made the subject of careful or scientific study. A few analyses are recorded of the soils of particular spots, and on two of the Government Experimental Farms a practical analysis of the soil has been attempted by growing crops on them with the aid of manures in which certain chemical elements have been alternately given or withheld. This has, however, been done without a previous knowledge of the soil and its constituents having been gained; has not been definitely known how much of each chemical element was actually supplied in the manures; nor was there any subsequent soil-analysis in order to see which constituents, and how much of each, had been removed by the cropping. Such experiments have a certain value, it is true, and may occasionally give some rough idea as to the needs or capabilities of a particular soil, but they fall far short of what may be gained by a systematic and scientific enquiry. I do not wish, however, to attach too high a value to the mere chemical analysis of soils as the index to all soil improvement, knowing well, as I do, the difficulties of interpreting the results aright, and, especially in the case of India, of applying the results in the form of recommendations that will be practically useful. It is not enough to ascertain that a particular ingredient may be wanting in a soil or be beneficial to a crop, but it is necessary, too, to know in what practical and most economical form that ingredient may be supplied, and whether, in effect, it will pay to apply it at all. In this respect India is very differently circumstanced to England, America, and other countries. Not only is there an absence of large landowners, but the few wants and scanty means of the cultivators, and the smallness of the holdings (averaging probably less than five acres each), make it necessary to consider measures of improvement from a special point of view. This has not been sufficiently borne in mind by those who have advocated "improved" implements and chemical manures for Indian agriculture. Even those (and Natives too) who have lived in England or have gone there to study have been disposed to exaggerate the value of chemical manures and chemical analysis of soils. While urging, as I shall do strongly, the employment of chemical and analytical skill in connection with the investigation of the soils of India, and in agriculture generally, I must not lead those whom I am called upon to advise, to expect too much from the researches of an Agricultural Chemist. Analysis of soils may do much to explain phenomena, and to suggest the lines of improvement, but it can, unaided, certainly not *reform* Agriculture. There is, however, without doubt, a large field open for enquiry, wherein the assistance of chemical analysis will be positively necessary, but it must be employed in conjunction with an intelligent acquaintance with agricultural practice and with the needs and resources of the agricultural classes, an acquaintance which can only come from a careful and systematic course of enquiry.

Variation in main types of Indian soils not so marked as in England.

45. In respect of different geological types of soil India exhibits far less variation than England. Soils of one main character stretch unchanged over infinitely wider areas, and the differences found in England on a single farm, necessitating special treatment and the growing of particular crops on each kind of land, are not often met with in India. Reference to the Geological Map given in this Report will show that the divisions are few in number and little varied over the country. They may be said to consist of three different kinds only, marked respectively on the map, brown (alluvial tracts), green (black cotton-soil), and red (hard rock). The vast alluvial plains composed of mud and sand stretch across the northern portion of the country from west to east; the second type or black cotton-soil is a basaltic formation, and occupies mainly the central and western divisions of the map; lastly, the hard rocky type, composed of archaean and metamorphic rocks, covers the southern and south-eastern divisions. In the next chapter I shall have occasion to point out how the effect of irrigation is altered by the existence of these different kinds of soil. Peaty soils are but little known in India, the chalky gravels and oolite soils, the marls and clays and other varieties met with in England are absent; in their place are found distinctive types in the "black cotton-soil," in the presence of concretionary nodules of carbonate of lime called *kankar*, and in vast alluvial plains and silt-renewed tracts.

Geological Map in "Statistical Atlas of India."

Types of soil.

Numerous subdivisions of soils.

Local classification.

46. Although the main geological types of soils are not so varied as in England, there are a large number of subdivisions, known by local names differing in each district, but the respective qualities of which are quite clearly understood by the cultivators. These minor differences, the result of variations in climatic conditions, in the system of manuring, and in the greater or less prevalence of trees and forest in the neighbourhood, are more numerous in India than in countries of more uniform climate and more similar agricultural practice and surroundings throughout. In several Provinces a regular system of classification of soils exists, and is used for Settlement purposes, while each district has its own classification under the particular local names given to the soils in each. In some Provinces every field even is classed according to its position, the nature and depth of the soil, the crops grown on it (whether it be wheat or rice or "garden" land), its nearness to the village site, &c., and particulars are recorded as to its being embanked, irrigated, or open to damage from water-channels, and whether it be exposed to injury from wild beasts, &c.

Desirability of instructing Revenue officials in agriculture.

47. On one occasion when I was in the Central Provinces, several Inspectors of Village Accountants (*patwaris*) and District Inspectors came to me; and, as we went over the fields together, I was much struck by the minute discriminations which they made between different varieties of soil, and by the interest which they took in this part of their work. They were, however, quite ignorant as to how soil came to be formed, and of the forces of nature, and of the causes which produce differences of soils. With a little sound instruction in agriculture, and in the elementary facts of science affecting it, these men would, I thought, have a much more intelligent understanding of agriculture, and of the conditions with which they have to deal in their daily work.

Improvement of soil—the directions in which it may proceed.

48. I come now to the improvement of the soil. This must take one of two forms: *first*, the rendering of cultivated land more productive; *second*, the reclamation of land, or the making fit for cultivation land which is now considered unculturable.

Is the soil of India becoming exhausted?

49. Under the first head the question naturally arises—Is the soil of India becoming exhausted? This is not an easy question to answer. Time after time it has been pointed out to me that the same fields have gone on growing the same crops on much the same system as at present, for centuries past; it is averred, too, that, by rotation and fallows, the land receives the necessary change of cropping and the "rest" from cultivation which prevents it from going down in quality. Further arguments are, that the rainfall contains more nitrogen in India than in England, that the sun acts as a fertiliser, and so on. On the other hand, there is a pretty general belief that the soil *is* becoming less productive, and remarks to that effect occur over and over again in the Settlement Reports of most able officers, obliging one to conclude that they are more than mere casual observations.

Want of positive evidence.

When, however, one looks for positive evidence of soil exhaustion, I admit that it is not forthcoming. Still, this does not prove that exhaustion is *not* going on. The want of evidence is due rather to the absence of reliable records in the past, and to attention not having been paid earlier to the crop out-turns. When the question as to whether the soil was deteriorating was asked by the Famine Commissioners, the reply received from Bengal was, that there were no means of ascertaining. This same answer might with truth have been given by all the Provinces, for the whole of the replies received were very indefinite, and dealt with surmises and with popular report rather than with actual facts. When investigating the subject myself, I hoped to find in Settlement Reports more definite information, deduced possibly from instances of assessment having been reduced; but, whilst a large number of instances are given where land had become unculturable owing to the spread of the efflorescence of soda salts known as *reh** (the land so affected being called *usar*†), there are but few cases mentioned in which actual deterioration of soil through continual cropping is stated to have taken place. Where, in the absence of *reh*, assessment had been reduced, it is impossible to ascertain whether any of the many other influences, such as fall in prices of produce, want of rain, indebtedness of the cultivators, or oppression of landlords (*zemindars*), has been the real cause of the reduction granted, or whether actual failure in the productive power of the soil has been brought about.

Difficulty of deciding the question.

It is hard to gauge out-turns, and to get to know what the soil is, by itself, capable of producing, or for what period the return from manured land will continue to differ from that of unmanured. Further, it has to be considered that, as fresh land is broken up, the manure supply, always limited and insufficient, has to be spread over a larger area than before. The opinion of cultivators must, I know, be taken as worth little, especially if it be given at a time when a re-settlement is imminent; the other opinions which I shall presently quote I give without wishing undue weight to be attached to them.

Theory that soil exhaustion proceeds to a certain limit and then stops.

On two points there is, however, decided agreement: *firstly*, that land newly brought under cultivation yields well at first, but that, after a time, the produce falls; and *secondly*, that, whether the soil be undergoing exhaustion or not, it is certainly not being enriched, nor is the average out-turn over the whole cultivated area an increasing one. This has led many to the conclusion that, while land newly broken up will yield largely for a time and then decline, this decline will not go below a certain level, and there it will stop. The instances of unmanured plots on the Experimental Farms at Rothamsted and Woburn in England have been quoted in support of this view; but these, though they show that, after a certain level has been reached, subsequent deterioration goes on very slowly, yet prove that it does go on.

Experience at Rothamsted.

The results obtained at Rothamsted in the case of a wheat crop continuously unmanured for 40 years are:—

	Average produce of Corn per acre in Bushels.
8 years 1844–51 (previous to commencement of experiment) - - - - - - - -	17
20 years 1852–71 (experimental period) - -	13·9
20 years 1872–91 „ „ - -	11·1

That positive evidence of exhaustion in the soils of India is not yet forthcoming is no proof, therefore, that the process is not slowly going on.

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* *Reh.*—An efflorescence of soda salts, which appears as a white crust on the surface of the soil and renders it unculturable. The salts are principally impure carbonate of soda, but sulphate of soda also occurs largely, and with them are found common salt and salts of lime and magnesia. *See* also paragraphs 67 and 74.

† *Usar.*—Land impregnated with soda salts, as above, and thereby rendered barren. *See* also paragraphs 73–76.

Instances in support of the view that exhaustion of soil is going on in India :—

50. I invite attention to the following instances which I have gathered, or which others have kindly collected for me :—

(*a*) from Coimbatore (Madras).

Mr. Nicholson, in his "Manual of Coimbatore," says :—

> " In Erode (Madras) the dry crops are usually poor ; the *taluk* has been
> " widely cultivated, so that the land has had no rest ; rainfall is variable
> " and partial, cattle are not abundant, and population is large, so that the
> " surface soil (and there is but scanty soil on the uplands) is exhausted for
> " want of sufficient manure, most of which goes to the gardens."

Again :—

> " The open sandy and treeless wastes south-east of Udamalpet, near the
> " foot of the hills, are melancholy instances of reckless tree destruction in
> " long-distant periods ; these were evidently rich jungles like those of
> " Anaimalai, but are now treeless and exhausted."

(*b*) from Gorakhpur (N. W. P.).

In the Gorakhpur (North-West Provinces) Report is the following :—

> " Although the productiveness of the soil contrasts favourably with that
> " of neighbouring districts, Mr. Wynne is of opinion that gradual deterio-
> " ration will necessarily result from the ruinous system of over-cropping
> " which is now practised. The fertility of the land is not maintained by
> " allowing the fields to remain periodically fallow, or by a sufficient use of
> " manure, or by a judicious system of rotation of crops. . . . .
> " In proof of the correctness of his impression in regard to prospective
> " general deterioration, he remarks that Tappah Sugurah, which has been
> " the longest inhabited, and twenty years ago was said by Mr. Chester to
> " be one of the most fertile, is now the least productive in the *pergunnah*,
> " and contrasts most unfavourably with Tappah Sehurree, of which the
> " soil was lately virgin. In a note on the Settlement of Gorakhpur Mr.
> " Reade referred back to a traditionary period when the district had been
> " one of the most productive and fertile in this part of India. It had
> " subsequently reverted to its primeval state of forest and jungle, from
> " which it has been gradually emerging within the memory of the present
> " generation. He concluded that it was liable at long and undefined
> " intervals to such periodical alterations, and anticipated a gradual deterio-
> " ration after cultivation should have been carried to a maximum."

(*c*) from Gonda (Oudh).

In paragraph 19 of the review of the Gonda (Oudh) Report is this :—

> " There is no alternate root crop known to the husbandry. A large
> " amount of animal manure is diverted from the land and used for fuel. . .
> " . . . . . The natural consequence is that over-cropping in time exhausts
> " even the best soils, and the culture during a series of years is unduly
> " low."

(*d*) from Purtabgurh (Oudh).

In the Purtabgurh (Oudh) Report occurs this :—

> " The soil, though fertile, bears evidence of exhaustion through want of
> " manure and fallow seasons. . . . . The root of the present
> " complaint, that the present yield is not equal to that of former times, lies
> " in the fact that under the native rule a field was seldom tilled for more
> " than two or three years in succession. In the third or fourth year a plot
> " of waste was broken up, while the whole land was allowed to lie fallow.
> " A succession of rich harvests was the consequence. Now, however, ...
> " competition steps in and prevents the resting of a single acre."

(*e*) from Lohardaga (Bengal).

In the Report on the agriculture of Lohardaga Mr. Basu writes :—

> " The fertility of the soil is being reduced fast to the permanent
> " limit by (1) continued cultivation without replacement by sufficient
> " manure ; (2) spread of cultivation (less forests and pasture, less cattle,

"and bigger areas to be manured); (3) cattle epidemics. The supply of "manure is extremely limited."

In another passage Mr. Basu says:—

"Fallowing used to be done, but is restricted owing to pressure of "population."

From the replies to enquiries addressed by the Famine Commission I take the following:—

(*f*) Instances from replies to enquiry of Famine Commission as to exhaustion of soil.

i. Central Provinces.

Central Provinces.—Mr. (now Sir Charles) Elliot in 1865 wrote:—

"It stands to reason that land, even the black soil of the Nerbudda "Valley, must deteriorate if it is cropped year after year without anything "being returned to it....... As long as half the first class was uncul-"tivated, and a new field could be broken up for every one thrown into "fallow, the crops (of the Nerbudda Valley) are not likely to have dete-"riorated much. But when once regular cultivation set in, and the "majority of the land came under the plough, a certain amount of "deterioration followed......."

"The old rate of produce in the golden age, or fifty years ago, is sup-"posed to have been tenfold, and, judging from the Tapti Valley...... "I do not conceive it can have been more than twelvefold. I reckon the "average now to be sixfold, and my belief is that it fell very rapidly from "twelvefold to about eight, and then rather slowly to six or seven; that "it was at that stage when the land was reported 'very much exhausted' "in 1830, and that it has fallen very slightly, if at all, since then."

ii. Madras.

Madras.—

"No Collector has reported that there has been deterioration of the soil "within his own experience, but some are satisfied, from the enquiries they "have made, that deterioration is going on....... The question of "deterioration does not specially arise in this Presidency with regard to "irrigated land. On the contrary, visible deterioration is apparent "chiefly in connection with unirrigated land newly taken up, and not "unfrequently relinquished again after some years in favour of another "fresh field, or one that has had some years' rest."

Under existing conditions of agriculture the soil of India must become gradually poorer.

51. The above extracts, while perhaps not furnishing absolute proof that the process of exhaustion in soils is going on, point to much more than mere probability of its existence. It must be accepted as an axiom in agriculture that what is taken off the land in crops must in some way be put back into the soil, or else the soil will suffer exhaustion. It is an equally accepted fact that the production of heavier crops means that more manure must be applied to the land. A country which exports both crops and manure must be declining in fertility. Now, what is the state of things as regards India? On the one hand there is a large export of oil-seeds, cotton, and other products, besides an increasing one of wheat, all of which remove a considerable amount of the soil-constituents. What is returned in their place? Only the straw or the stalks and leaves; and it is not even correct to say that these are returned, for, after all, it is only a portion, and frequently a very small portion, that does find its way back to the soil. Part is necessarily used up in the bodies of the cattle, part is wasted by imperfect conserving and storing of manure, part must unavoidably be lost, however great the care that may be taken; thus it comes about that it is only a fraction that contributes finally to making up the loss the soil has sustained.

Were, on the contrary, all grain to be consumed by the people, and all night-soil to be used in agriculture; were all refuse of oil-seeds (after pressing out the oil) to be utilised for manure; were all straw to be consumed by cattle, and the droppings, solid and liquid together, to be carefully preserved; lastly, were all stalks and leaves to be buried again in the land; then the balance might be more nearly preserved. But, as things are, the exports of oil-seeds, grain, &c. (that of bones I will discuss later) simply mean so much of the soil-constituents *carried off*, for which no adequate recompense is made.

The consequence must be that the soil becomes gradually poorer, though the effect may not as yet be visible to the eye; for, even if the soil be still producing the same crops, the *potential fertility* (by which I mean the reserve of constituents for the production of future crops) must be suffering loss, and the capabilities of the soil must be less than under a system of equal giving and taking. In face, therefore, of the enormous increase recorded in the population, and future increases that will have to be met, it becomes a most serious question how the food for these millions is to be found; in other words, how the manure is to be obtained without which the crops necessary for feeding these people cannot be grown.

The problem of the future.

52. I cannot, therefore, agree with the theory that fixes a certain level to which production may sink, but below which it will not go. This is apparent rather than real. The decline may be slow, but this is a mere matter of time. When we compare the wheat-yields of different countries, we have, as nearly as one can judge, the following:—

Wheat-yields of different countries.

TABLE I.—Wheat-yields of different Countries.

—	India.†	United‡ Kingdom.	France.	Germany.	Russia.	Canada.	United States of America.	Australia.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
Average yield per acre in bushels* -	10	28	17	18	9	14	12·5	11

* Taken from the Agricultural Returns of the Board of Agriculture, 1890.

† Average of the five years ending 1883–84, as given in the Government of India's statistics. The average yield in 1889–90 was 9·4 bushels only.

‡ Average of the last 40 years. The average of the last eight years was 30 bushels.

The wheat-yield in India will vary, not only according to the season, but also with the conditions under which the crop is grown; for instance, it must be taken into account whether the land be manured or not, whether it be land dependent on rainfall alone, or supplied by irrigation as well, and whether rainfall be sufficient or not. As nearly as a conclusion can be formed, the following are the out-turns on some of the respective classes of land:—

On unmanured dry-crop land where rainfall is precarious and often insufficient - - - - - -	7 bushels per acre.
On manured land in tracts of better rainfall - - - - -	10 " "
On manured and irrigated land -	15 to 25 bushels per acre.

In comparison with the above, it may be mentioned that in the Rothamsted Experiments the produce of land continuously unmanured for 40 years is 12½ bushels per acre, at 61 lbs. per bushel.

Possible explanation of any decline in soil fertility not being apparent, though really existent.

53. The real answer to the question whether the soil of India is becoming exhausted or not, seems to me to lie in the fact of the small produce annually removed. In England, with its 28 to 30 bushels per acre, what is removed over and above the yield of the unmanured land is due to what is put into the land in the form of manure: India's 10 bushels, on the contrary, represent almost entirely what is taken out of the soil itself. The extra crop in England is, in other words, the produce of what is *added to*, and not, as in India, the produce of what is *taken out of*, the soil.

Nevertheless, the powerful sun of India, aided by moisture, or by water (where it is applied artificially), exercises, I believe, a far more rapid and powerful influence in decomposing and bringing into an assimilable condition the constituents of the lower layers of the soil and of the stones and rocks which go to produce soil than is the case in England; and why no decline is noticed, after a certain limit has been reached, may be due to there being just enough fresh material decomposed and brought into active condition annually to produce the requisite small yield. It must not be forgotten, it is true, that the wheat crop of England is generally a nine months' crop, that of India only a five months' crop; but I believe that the influences named above are the most potent factors in causing the differences of yield. Were demand, however, made upon the soil for a greater yield, the soil could no longer supply it, and it would have to be met by outside sources, in other words, by manure.

Importance of the question of manure supply.

Such a demand must be looked for in the rapidly increasing population, and in the greater difficulty of providing food for it. Sir James Caird, in treating of this problem, estimated that if the produce of the land could be increased by one or two bushels per acre the difficulty could be met. It will be my endeavour to show in this and the following chapters that the necessary increase can only be met in one way, viz., by improving the *manure supply* of the country. Improvement in the system of land tenure, improvement of the land by expenditure of public and private capital on it, and similar measures, may alleviate the condition of the Indian cultivator, but they will not give him larger crops, and they will not provide the food that the people *must* have to live upon. For this the *soil* itself must be looked to, as it alone can produce the crops, and *manure* alone can enable it to bring forth the necessary increment. The question of manure supply is, accordingly, indissolubly bound up with the well-being and even the bare existence of the people of India.

Study of the constituents of the soil.

54. Having considered the soil as a whole, and chiefly in regard to the important question of its deterioration or the reverse, it is well that I should now discuss the separate ingredients which go to make up soil, and which cause the differences between one soil and another. The main ingredients are the following:—water or moisture, vegetable matter or *humus*, sand, clay, and carbonate of lime. These I shall take as presenting themselves in a chemical study of Indian as distinguished from English soils, and, in addition to pointing out the most characteristic differences, I shall endeavour to indicate possible lines of further enquiry.

1. Water or moisture.

Special importance in India.

55. First to be considered among the components of cultivated soil is Water or Moisture, without which no germination is possible. In India the relation of soils to moisture acquires a greater significance than almost anywhere else, on account of the rainfall being limited to particular periods, instead of being distributed throughout the year, and because of the intense and prolonged heat, with consequent rapid evaporation. Climatic conditions, as shown in Chapter IV., exercise most marked influences upon Indian Agriculture, and cause the practice of it to vary greatly in different parts.

Relation of soils to moisture.

Alluvium.

Hard rocky soil.

Black cotton-soil.

A striking difference is seen between the condition of English soils and that of the generality of Indian soils. Speaking broadly, it may be said that the normal state of an English soil is "wet," and that of most Indian soils "dry;" and whereas, in the case of the former, the object is generally to *get rid of* the superfluous water by means of drainage, the difficulty in India is, as a rule, to *keep the moisture in* the land. The relative behaviour of soils to the moisture which falls on them in the form of rain, or which is conveyed to them by artificial means of irrigation, is, therefore, of great importance. The differences of geological types of soil mentioned in paragraph 45 must be here again borne in mind, and reference to the Geological Map will assist the explanation. The alluvial soil (coloured brown on the map) which occurs in the Punjab and North-West Provinces, under conditions of a dry climate, low rainfall, and hot sun, soon loses its moisture and becomes baked, so that dependence has largely to be placed on irrigation, and the more so where the alluvium (or mixture of sand and clay) is sandy rather than clayey in character. So, too, the hard rocky formation (coloured red) of Southern and South-eastern India calls for the same measures. But where, as in the Central and Western parts, the black cotton-soil (coloured green) occurs, we find a great difference, for this soil is naturally very retentive of moisture, and as it dries it cracks into blocks which, though hardened and baked externally, will be found, on being broken open, to have enclosed moisture within them, and to have thus prevented it from being lost. So it comes about that there is always sufficient moisture for the germination of the seed, and for the growing of the crop. Irrigation, consequently, is not necessary in these parts, and famine is of rare occurrence.

Soil of tracts along river beds in the Punjab.

There is another class of soil, that found in the tracts along the river beds of the large streams in the Punjab, which always has a sufficiency of moisture in it, although not actually inundated. With this exception, and that of the black cotton-soil, it may be said that in the majority of cases great importance attaches to the retaining of moisture in the soil. I have often been struck by the attention which the cultivator gives to this, and have noticed with surprise how, even under the influence of a burning sun, the land, by reason of the careful preparation given to it, is made to retain sufficient moisture to ensure the germination of the seed put into it, for, on turning up the earth to a depth of two, or at most three, inches, the precious water will be found in it. In indigo-planting this is absolutely essential, and great is the care taken to break up and pulverise each crust that forms on the surface. I cannot help suspecting that the system of shallow ploughing, as practised by the Native, and his aversion to ploughs that turn over a broad slice and form a wide furrow, may have something to do with this matter of the retention of moisture, and that the effect of deep ploughing would too generally be to lose the very moisture the cultivator so treasures.

Importance in most cases of retention of moisture in soil.

Shallow ploughing.

Improvement of soil by increase of water supply to dry tracts.

56. From the foregoing remarks it follows that one obvious direction in which improvement in soil can be effected, is the increasing of the supply of water to dry tracts, and thus of moisture to the land. The means by which this may be done will be more specially treated in the next chapter, and it will suffice here to say that for any work to be carried out on a large scale it must be done by Government or by Government aid.

This the work of Government.

Harm occasioned by over-irrigation.

57. While I have drawn attention to the importance of the retention of moisture in the majority of soils, it must nevertheless be remembered that this principle cannot be enforced everywhere, and that there are some instances of its misapplication, as in the making of canals where they were not really wanted. Orissa is a case in point.

There is little room for doubting that, by the introduction of canals into tracts where there was no real necessity for them, the soil has suffered from the removal of its valuable constituents through the continual washing process to which it is subjected, and also that a system of over-cropping (beyond what the soil can bear) is frequently consequent upon the introduction of canals. Other results attributed to canals are, the spread of *reh* (*see* footnote, p. 37), the increase of fever through the raising of the water-level of the country, and the destruction of wells.

These various points will be dealt with in the next chapter. It is necessary, however, to interpose here the caution that, while, in by far the greater number of instances, the supply of water to and retention of moisture in the land is of the highest importance, it does not do to lay down a universal rule, and there are cases where any further supply of water would be attended by positive harm, or where measures for the *removal* of water might even be called for.

2 and 3. Organic matter and Nitrogen.

Humus, its origin and functions.

58. The next soil-constituent to consider is that which is variably termed "Vegetable matter," "Organic matter," or "*Humus*." Along with it it will be convenient to take Nitrogen also, inasmuch as this constituent is, in measure at least, derived from *humus*. Though, apart from water, the carbonaceous constituents form the largest portion of ordinary crops, these are derived not from the soil but from the atmosphere, and therefore do not concern us so particularly here. But the vegetable matter or *humus*, which has its origin in the dead roots and leaves of a previous vegetation, or in a previous manuring with organic materials, exercises a distinct influence on vegetation, for, though probably not directly assimilable by crops, it is the principal nitrogenous ingredient of soils, and on being further oxidised will yield carbonic acid, ammonia, and, lastly, nitric acid. This is effected by means of a nitrifying organism or *bacterium*, which occurs in fertile soils, and most abundantly in the surface soil. The nitrates or salts of nitric acid thus produced are the form in which nitrogen can be taken up by plants as food.

There are also *physical* advantages in the presence of vegetable matter in soils; such as, the binding together of sandy soil, the retention of moisture, the increase of porosity in clay soils. Further, the presence of vegetable matter in the soil has an indirect influence on the climate, inasmuch as soils rich in it absorb more heat from the sun's rays than do light-coloured sandy soils, which are generally deficient in *humus*, and in consequence radiate out more heat.

Organic matter and Nitrogen in Indian soils.

On looking into analyses of Indian soils which have been recorded, and others which I have made myself, I find that, with the possible exception of black cotton-soil, Indian soils are generally very deficient both in organic matter and in nitrogen. The following analyses will illustrate this :—

TABLE II.—Organic Matter and Nitrogen in Indian Soils.

——	I. Cawnpore Farm Soil. (S.A.Hill.)	II. Soil from Arrah, Behar. (E. Kinch.)	III. Soil from Siripur, Behar. (E. Kinch.)	IV. Dumraon Farm Soil, Behar. (E. Kinch.)	V., VI., VII. * Three Soils from Wheat-growing Land in Sirsa District, Punjab. (J. A. Voelcker.)		
Soil (dried at 212° F.) contained :—	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Organic matter and combined water	2·20	1·74	2·77	5·53	0·63	2·67	0·65
Nitrogen - -	·028	·025	·073	·05	·07	·02	trace.

* For full analyses *see* Appendix A.

In the foregoing analyses the organic matter is not stated alone, but along with it is the water which is chemically combined with the mineral constituents, and which is not removed at a temperature of 212° F. Accordingly, the organic matter appears more than it really is, but, when compared with ordinary fertile English soils, the quantities, with the exception of No. IV., read low, and in some cases extremely so. In every instance the amount of nitrogen is small, and considerably below that found in the average of English agricultural land.

Indian soils generally deficient in organic matter and nitrogen.

A person with knowledge of agricultural chemistry will readily understand that such soils as the above can be considerably benefited by the application of cattle-manure, by green-manuring, or by the use of other organic and nitrogen-containing materials.

Functions of nitrogen.

The importance of nitrogen is emphasised when it is explained that in the case of cereals the assimilation of starch is dependent upon the amount of nitrogen supplied to the plant, and that it is the nitrogen which helps to bring the different mineral constituents of the soil into action. It is not enough to have mineral constituents present in the soil, but there must also be nitrogen, in order to render them available for the plant's use.

It becomes necessary, therefore, to enquire very carefully into the sources from which nitrogen may be derived, and whether the deficiencies already noted may not be made up in some way or other.

Erroneous idea that rainfall in India contains much more nitrogen than in England.

59. A considerable quantity of nitrogen in the form of ammonia and nitric acid is conveyed to the soil in rain. The knowledge of the importance of nitrogen, and of its frequent deficiency in Indian soils, has led to an incorrect idea that the rainfall in India contains much more nitrogen than it does in England and other temperate climes, and that by this means the deficiency of nitrogen is met, and this important element is supplied to the crops. This statement has been copied over and over again into books, and has been pointed to in support of another erroneous opinion, viz., that practically no loss is incurred by the burning of cattle-manure, so long as the ashes are used, because the nitrogen that passes off in the burning is supposed to come down again in the rain. I have paid special attention to examining the evidence on which these theories are based, and I have ascertained that the original analyses which gave rise to them were incorrect, in consequence of the impurity of the chemicals sent out from England. Dr. Van Geyzel, Chemical Examiner for Madras, has been kind enough to give me the information on this point, and also his own later analyses, from which it will be seen that the amount of nitrogen in the rainfall, as *now* returned, was, in 1888, only one-thirteenth, and in 1889, only one-twenty-fifth portion (4 per cent.) of what was stated to be the amount in 1885–86! The following are the results, and by the side of them are given those of more recent analyses of rainfall made by Mr. Warington at Rothamsted, Hertfordshire, England :—

Nitrogen in Rainfall of India and England.

TAPLE III.—Nitrogen in Rainfall of India and England.

—	MADRAS.	MADRAS.	MADRAS.	ENGLAND (ROTHAMSTED).
	Twelve Months, September 1885 to August 1886.	Twelve Months, January to December 1888.	Twelve Months, January to December 1889.	Twelve Months, May 1888 to April 1889.
Rainfall in inches - - - -	64·77	62·48	43·38	29·27
Total nitrogen reckoned as ammonia, lbs. per acre -	* 52·338	3·997	2·114	4·54

* Incorrect result.

From these results it would appear that the rainfall in India, instead of having *more* nitrogen, has actually *less* than in England. I do not say absolutely that this *is* the case, for Madras may not be typical of all India. Besides, its situation near the sea causes the composition of the rainfall to vary greatly at times, and to contain more chlorides, especially at cyclone periods, than would be the case at inland places. What, however, I do say is, that it has not been shown that Indian rainfall contains *more* nitrogen than English, and the arguments based on the presumption that it *does* are altogether faulty.

Fixation of nitrogen from the atmosphere.

60. If, however, not from the vegetable matter, because less in amount, nor yet from the rainfall, because not richer than in England, we are to look for a compensating supply of nitrogen for that removed in crops, there is still another source the importance of which has been brought to light by quite recent scientific investigations—the utilisation of the nitrogen of the atmosphere itself. The researches of Hellriegel, Wilfarth, Prazmowski, Nobbe, and others, and now confirmed by the further experiments of Lawes and Gilbert (which are still in progress), have fairly established the fact that, though plants have not the power of absorbing the free nitrogen of the air directly through their leaves, yet, in the case of the *Leguminosæ*, the nitrogen is fixed in the course of the development of the organisms contained within the nodules which form on the roots of the *Leguminosæ*, and the resulting nitrogenous compounds are absorbed and utilised by the host, that is, the Leguminous plant. At present the evidence indicates the probability that this action is limited to *Leguminosæ* of the Sub-order *Papilionaceæ*.

Recent investigations.

Leguminosæ in India.

No enquirer going over India could fail to be struck by the enormous preponderance of trees, crops, and even weeds that belong to the Natural Order *Leguminosæ*. Almost everywhere the *babul* (*Acacia arabica*) is seen, with many other leguminous trees; gram (*Cicer arietinum*), *arhar*

(*Cajanus indicus*) and numerous varieties of pulses, indigo, &c., are among the commonest crops, and are all highly nitrogenous; lastly, leguminous shrubs and weeds abound, and are often spread on the land or ploughed in as manure. How can this be in a soil naturally poor in nitrogen? The recent investigations referred to point to a strong probability that the conditions of India are peculiarly favourable to the fixation of atmospheric nitrogen through the medium of the nodules that are known to form on the roots of certain of the *Leguminosæ* at least. Support is given to this by the fact that quite lately, in Germany, Nobbe and Frank have found these nodules on the roots of leguminous shrubs, as well as in the case of the clovers and pulses that form our ordinary European leguminous crops.

Field for enquiry.

A fertile field for investigation is herein set forth, and India, to my mind, presents special advantages for the elucidation of the problem, one which, when solved, will unfold much that is still unexplained in the advantages of rotation of crops.

Organic matter and nitrogen in black cotton-soil.

61. The special case of black cotton-soil and its properties has been mentioned, and this, again, offers a field of enquiry, for its origin and its qualities are not fully understood. It is believed in some parts to be derived from basalt by surface decomposition, in others to be the impregnation of argillaceous earth with organic matter. Carbonate of lime is present to a considerable extent in black cotton-soil. In depth this soil varies greatly; at Akola it is from 40 to 60 feet deep, but further away it thins out to 19–20 feet, and after that gets quite shallow. In the rains it becomes quite impassable. It is generally supposed to require no manure and to be incapable of exhaustion. That it has peculiar powers, there is no question, but that it is so rich in vegetable matter and in nitrogenous ingredients as to be independent of manure, I do not think. I have not had the opportunity of studying it specially, but I give the following results from an analysis of black cotton-soil by the late Mr. S. A. Hill, and from one which I made of a specimen of this soil from Akola, in Berar:—

TABLE IV.—Organic Matter and Nitrogen in Black Cotton-soil.

———	I. Black Cotton-soil from North-West Provinces, near the Jumna. S. A. Hill.)	II. Black Cotton-soil from Akola, Berar. (J. A. Voelcker.)
Soil (dried at 212° F.) contained:—	*Per Cent.*	*Per Cent.*
Organic matter and combined water - - - - -	4·95	3·83
Nitrogen - - - - -	·034	·036

The amounts of nitrogen are very low, and though there is more organic matter than in the soils tabulated in paragraph

58, yet the quantities are not really large. Support is given to my belief as to the condition of this soil, by the increasing practice, among the better cultivators, of manuring it. It was stated in Settlement Reports of the Nerbudda Valley some 25 years ago, that it was not the custom to use manure, but now in Saugor and Damoh it is by no means uncommon to find manure used, and the people all say that they want more.

4 and 5. Sand and Clay.

62. From the organic portion of the soil we may now pass to the principal inorganic or mineral ingredients, viz., sand, clay, and carbonate of lime. According as the sand or the clay (which is, chemically, a silicate of alumina) predominate, so we find differences in the water-retaining powers of soils, for sand has the least, and clay the most, power of holding water. This is well illustrated in the alluvial deposits brought down by rivers and streams, and which form the vast Indo-Gangetic plain. These are composed of alternating layers of sand and clay, and as the transported materials, whether the heavier sand or the lighter clay, have been deposited on any spot to form there the surface soil, so may variations be found in the soil's water-holding capability. In parts, such as the sandy desert plains of the Western Punjab and Rájputana, the surface soil is principally sand, owing to its deposit there, while the finer and lighter clay has been carried on farther. Such soil, in the absence of water, is little more than desert land. In other parts, clay may predominate and water be better retained.[*] On the other hand, capillary attraction, or the force by which water is brought up from the subsoil to the surface during dry weather, is more active in clays than in coarse sands, and evaporation is more rapid from a consolidated surface than from an open and well-tilled one. So it is that the incrustations of soda salts known as *reh* (*see* footnote, page 37) are found on the clayey rather than on the sandy lands. Again, a sandy soil is a better conductor of heat than a clayey one, and, being thus more rapidly warmed or cooled than a clay, is not so likely as the latter to become "baked."

To show the variations that occur between soils even at no great distance apart, I give the following results from mechanical analyses by Professor Kinch, of Cirencester, of soils from Dumraon, Arrah, and Siripur, in Behar, sent to him by Mr. D. B. Allen :—

TABLE V.—Sand and Clay in Indian Soils.

	I. Dumraon Farm Soil.	II. Soil from Arrah.	III. Soil from Siripur.
Soil (dried at 212° F.) contained :—	*Per Cent.*	*Per Cent.*	*Per Cent.*
Coarse sand	10·3	28·6	2·7
Fine sand	8·0	32·0	46·3
Clay, &c.	81·7	39·4	51·0

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[*] The alluvial plains of India may be said to contain four types of soil: (1) heavy loam of Bengal, where clay predominates; (2) heavy loam with clay and some sand; this is found in the inundated land of Northern India, and the soil remains in clods; (3) light loam of Behar and parts of the Punjab; here the clods fall to pieces; (4) very light loam and sand of some parts of the North-West and the Punjab.

6. Carbonate of lime.

Kankar.

63. The remaining principal ingredient of soil is carbonate of lime. Reference has already been made to the peculiar concretionary form of limestone known as *kankar*, which occurs largely in India. These lumps are found near the surface, and are, doubtless, the result of the evaporation of water containing in solution lime which has been obtained by the decomposition of the mineral portions of the soil. Now, lime works beneficially in many ways; it not only acts itself as a plant food, but it makes clay land permeable to moisture, and enables it to absorb potash, ammonia, and other salts, whilst, not least of all, its presence is required in the process of nitrification, by which means nitrogenous matters in the soil are made available for the plant's use.

Speaking generally, lime is more plentifully distributed in Indian soils than in English; that is, deficiencies of it are not so frequently met with. A notable exception, however, which I have found, is in the laterite soil of parts of Southern India, such as the coffee-growing districts of Coorg and Mysore, and the tea plantations in the Neilgherries, where, I have reason to believe, a more abundant supply of lime would be decidedly beneficial.

Lime in Indian soils.

The following analyses exemplify these points :—

Table VI.—Lime in Indian Soils.

———	I.	II.	III. *	IV. *	V. *	VI.	VII.	VIII. †	IX. †	X. †
	Black Cotton-soil, near the Jumna, N. W. P. (S. A. Hill.)	Cawnpore Farm Soil. (S. A. Hill.)	Wheat-soils from Sirsa, Punjab. (J. A. Voelcker.)			Dumraon Farm Soil. (E. Kinch.)	Soil from Arrah. (E. Kinch.)	Coffee-soils from Munjerabad, Mysore. (J. A. Voelcker.)		
Soil (dried at 212° F.) contained :–	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Lime - - - - - (calcium oxide, CaO.)	3·66	·90	1·65	1·44	1·86	1·00	·66	·20	·32	·32

Lime generally abundant.

The amounts of lime in Nos. I.–VII., inclusive, are more than in most cultivated English soils; but in Nos. VIII.–X. a marked difference is apparent. Of the majority of Indian soils it may, however, be said that they contain a sufficiency of lime.

7, 8, 9. Iron, Alumina and Magnesia.

64. Having taken now the principal ingredients of soils, we may pass on to those soil-constituents which, while found in lesser amount, are, nevertheless, those which exercise a great influence on the productive power of soils. Of these the principal are phosphoric acid, potash, and soda, and they are the only ones that need be dwelt upon separately. Other constituents such as iron, alumina, magnesia, &c., which are found in soils and which enter into the composition of plants, do not call for special reference. Iron is a widely-distributed element in soils, and occurs largely in the laterite soils of South-western India, notably in the coffee-soils of Coorg and Mysore. This laterite is a porous argillaceous rock, impregnated with iron peroxide (hydrated), of which it may contain 25 to 35 per cent. Alumina enters into the composition of all clays, but magnesia, so far as I know, acquires no special importance in Indian agriculture. Magnesia appears to exist in sufficient abundance throughout, and more plentifully than in English soils.

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* For full analyses *see* Appendix A.

† For full analyses *see* Appendix B. These soils had been cultivated for 30 years previously, and only had bones in small quantity supplied to them.

10. Phosphoric acid in Indian soils.

65. Phosphoric acid I believe to be more abundantly distributed in Indian than in most English soils. There are but few analyses to refer to, in consequence of the absence of any investigation in India from the standpoint of agricultural chemistry, but what analyses there are seem to show that there is, happily, not that pressing need for the additional use of phosphatic, and I may add for mineral manurial elements generally, that there is in England. In the latter country, if a soil contained 0·12 or 0·13 parts of phosphoric acid in 100 parts of the dried soil, this would be reckoned a good average amount, and 0·17 per cent. would be decidedly above the average. From analyses of Indian soils I quote the following results, giving, for convenience, the determinations of potash in the respective soils at the same time:—

Table VII.—Phosphoric Acid and Potash in Indian Soils.

—	I. *	II. *	III. *	IV.	V.	VI.	VII.	VIII. †	IX. †	X. †
	Wheat-soils from Sirsa, Punjab. (J. A. Voelcker.)			Cawnpore Farm Soil. (S. A. Hill.)	Dumraon Farm Soil. (E. Kinch.)	Soil from Arrah. (E. Kinch.)	Black Cotton-soil from the Jumna, N. W. P. (S. A. Hill.)	Coffee-soils from Munjerabad, Mysore. (J. A. Voelcker.)		
Soil (dried at 212° F.) contained:—	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*	*Per Cent.*
Phosphoric acid - -	·17	·23	·19	·51	·10	·09	·11	·13	·15	·10
Potash - - - -	·39	·74	·31	·32	1·58	·50	·28	·25	·10	·10

Although variations are shown in these results as regards the phosphoric acid present, in no case are there the marked deficiencies frequently met with in England, and, taking the four first-named soils as representative of a great tract of wheat-growing land, I should consider them especially well supplied with phosphates. This may possibly have some bearing on the question of the utilisation of bones in India as against their export. If a soil show no deficiency of phosphates, there may lie in this the explanation of the fact that bones have not as yet been clearly proved to be beneficial or necessary to a number of Indian soils.

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* For full analyses see Appendix A.
† For full analyses see Appendix B.

The utilisation of bones as manure.

On the other hand, the somewhat lower amount of phosphoric acid found in the laterite soils of Mysore, together with the greater demands of the coffee plant upon the mineral ingredients of the soil, may be the reason that bones are in these parts used extensively by the planters, and are considered necessary. The benefit of their application may lie also in the fact that they supply lime and nitrogen as well as phosphoric acid.

11. Potash in Indian soils.

66. Potash, like phosphoric acid, is a very important plant food. It appears to be well distributed, and its additional supply to be only exceptionally called for in Indian soils. For growing ordinary farm crops in England 0·25 per cent. of potash in a soil would be reckoned a fair amount, but, as will be seen from the table given in the last paragraph, Indian soils may contain considerably more. Only in the coffee-soils, Nos. VIII.–X., do we find what may be termed a deficiency.

Nitre.

In many parts of India, and notably in Behar, Nitre (nitrate of potash) is found impregnating the earth, especially on spots where habitations have stood before. The earth is lixiviated with water and the nitre is extracted in an impure state, after which it is purified by boiling down the solution and crystallising out the nitre.

12. Soda in Indian soils.

67. Soda, when potash is also present, can hardly be regarded as an essential constituent of plant life, and in India there is no lack of it. Indeed, the existence of soda salts in large quantity in the soil of some parts of India gives rise to an exceptional feature in the agriculture of the country. The selective power of plants for food is well known, and their preference for potash-containing rather than for soda-containing salts has been well established. But in some parts of India, soda salts are present in the soil to such quantity as to positively destroy vegetation. The salts are brought up from the subsoil by the combined action of water and the sun's heat, and then crystallise out on the surface, forming a kind of "snow" which is termed "*reh*,"* and the land thus affected is known as "*usar*"* land. The composition of *reh* is not uniform; most generally carbonate of soda is the prevailing ingredient, at other times sulphate of soda, but both occur together, and associated with them in more or less quantity are common salt and salts of magnesia and lime. Of the origin of these salts there is no positive certainty, but they are most probably the salts which are dissolved out on the gradual decomposition of igneous rocks, and are subsequently deposited when the water which holds them in solution evaporates. That they may be afterwards brought to the surface, depends on two conditions being present—first, water to percolate down to

Reh and *usar*.

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* See footnotes, page 37.

the subsoil and to re-dissolve the salts; secondly, a strong evaporative force, such as the sun's heat, to draw them up and then crystallise them out upon the surface. I am unable to say either what amount of salt is met with in any particular soil, or what quantity is found in practice to be injurious, nor yet, again, whether the carbonate and the sulphate of soda are equally injurious to vegetation, for, strange as it may seem to English men of science, the whole of the enquiries that have been conducted in India on the *reh* question have been carried out without associating with them any agricultural or even general chemist. I have little hesitation in saying that, owing to this want, much information that might have been gained, and which would have aided the enquiry greatly, has been lost, and that speculation and guess-work have been indulged in where it would have been possible, had an agricultural chemist been at work on the subject, to have obtained certain knowledge.

Need of an Agricultural Chemist, as illustrated by the *reh* enquiry.

The question of how to deal with *usar* land, with a view to its reclamation, will be dealt with later on (*see* paragraph 73 of this chapter). It will suffice to say here that deficiency of soda is not met with in Indian soils, so far as I know, but there are, on the contrary, many instances of its presence in excessive and injurious quantity.

Improvement of soil by increase of manure supply.

68. The improvement of the soil in respect of any deficiency in the constituents named in paragraphs 58–67, must be effected by manuring. The consideration of this subject, and of the means available in India, will come more appropriately under Chapter VII. (Manure) than here. It is evident, however, that the increase of the manure supply for the purpose of enriching the soil is an important factor in the improvement of Indian Agriculture. To anticipate my conclusions, I would say that here again, as with the supply of water to dry tracts, the work will have to be initiated by Government; while, for the purpose of knowing what supplies are available, and what remedies can be effected, there is need of careful and scientific inquiry.

The work must be initiated by Government.

The improvement of soil by making land fit for cultivation.

69. I pass on now to the second of the two heads given in paragraph 48, under which agricultural improvement may take place, viz., the reclamation of land, or the rendering fit for cultivation land which is now considered unculturable. Under this head are reckoned ravine and similar waste land, land infested with *kans* grass (*Saccharum spontaneum*) and other weeds, and, lastly, saline or *usar* land.

Reclamation of ravine land.

70. Reclamation of ravine land may take place in two different ways—either by covering it with trees, shrubs, and grass, or by making the land itself fit to bear crops. The consideration of the first part of this subject will come more appropriately in Chapter VIII. (Wood), when dealing with the question of wood supply; but it may be incidentally remarked that the growth of trees and grass implies an improvement of the soil itself, in that it becomes enriched by the accumulation of vegetable matter or *humus* derived from the decaying of the leaves that fall upon its surface, as also from the herbage that grows on it, and which gradually dies down. It is not often that land cut up by ravines can be levelled, and the whole area be thus turned into a culturable space, but much can be done to localise the effects of the floods that wash down and sweep before them the fine topsoil. In many cases these floods can be prevented from spreading their destructive influence further, and from injuring the lands that lie beyond them. The work of actually levelling ravines is too great and too expensive a one to contemplate, save in exceptional circumstances. Here and there an individual proprietor, having a large holding and also capital, may do it, and Government may also initiate it as a means of protection, or as "famine work," but it cannot be looked on as remunerative. Much, however, may be done by throwing embankments across the *nullahs* or channels made by ravine streams, and thus holding up the water and preventing the continual washing away of the surface soil. I give instances of what has been already done in this direction.

Embankment of ravine streams.

Captain Chapman's work at Bâti.

Captain Chapman, on his estate at Bâti in Oudh, has carried out embankment of land on a large scale. He has thrown masonry dams or *bunds* across 13 channels (*nullahs*) which had been cut by the rain water pouring down off the higher land, and he now uses the reservoirs thus made by the collected water for irrigation purposes. Captain Chapman has also reclaimed some of the ravine land by terracing it.

Experiments at Jhansi.

At Raksha, near Jhansi (N. W. P.), an experiment was begun in 1888 by the then Commissioner, Mr. G. Ward, to see whether the denudations of the hilly country around could be stopped by making embankments which would hold up the rush of water in the rainy season, and prevent it from washing the topsoil away. It was thought that fertilising deposits of silt might be formed near the embankments, and that, as the water soaked into the ground, land might be left which would be readily culturable; while, if the water did not disappear, it would serve for irrigation use. The soil is thin, with rock underlying it, and wells are very difficult to construct. There is evidence that, in former days, when the country around was richer, the Natives used to throw up similar embankments, and that the large proprietors used to construct dams to hold up the water; but these have now been let fall into disrepair. Mr. Ward in 1888 began to throw up a series of embankments or *bunds* of earth, and at present 30 such have been made; the slopes have been sown with *babul* (*Acacia arabica*), and grass is covering the sides. As yet, owing to deficient rainfall, not enough water has collected to be used for irrigation, nor have the beds been cultivated, but the trees have grown fairly, and the grasses are improving, *dûb* grass (*Cynodon Dactylon*) having spread considerably. It is said that the Station of Jhansi is cooler since these works have been made.

Reclamation at Cawnpore.

At Nawabganj, near Cawnpore, I saw 220 *bighas* of land (1 *bigha* = $\frac{5}{8}$ acre), which, six years ago, was waste ravine land under the Court of Wards. An enterprising Native became proprietor of this area, levelled it, and then let it out to cultivators. It is now rented at Rs. 5 per acre.

Reclamation at Etawah.

Again, at Etawah (N. W. P.), although the ravine land there is converted into a "Fuel and Fodder Reserve," yet, where the ravines lead down to the river (the Jumna), cultivation is carried out on every bit of land that offers itself, and crops are grown partly on the soil washed down from the higher ground, partly on the silt washed up by the river. If in such places the first rush of water that takes place during the rains were stopped by embankments, then the good soil might be collected instead of being washed away into the river, and not only would more soil be available for cultivation, but the water might be held up for irrigating the land. Ravines such as those at Etawah extend all along both banks of the Jumna and Ganges rivers.

Reclamation of other waste land.

71. There may be other waste land besides *usar* and ravine land which is capable of reclamation.

Lake land at Bâti.

I saw with great interest at Bâti (Oudh) the 7,000 *bighas* (*bigha* = $\frac{5}{8}$ acre) of land which Captain Chapman had, with extraordinary energy, reclaimed. Formerly it was one vast lake into which the Ganges, when in flood, poured each year. What Captain Chapman did was, to shut out the Ganges entirely by constructing a massive embankment or *bund* 7 miles long, and he then proceeded to pump the water back into the river. This work, begun in 1873-4, is now nearly complete, and what before was a lake is now culturable land thrown into the property. With the help of steam ploughs and pumping engines the land has been tilled, drained, and also irrigated, and the soil, being naturally very rich, can grow splendid crops without any manure.

Reclamation of land from the sea.

At Máhim (Thána, Bombay) a good deal of land near the sea has been reclaimed by embanking it so as to keep out the sea.

"Choh" land in the Punjab.

The enormous stretches of "choh" land in the Punjab, notably near Hoshiarpur, present a serious problem in the way of reclamation. Streams come rushing down from the hills, bringing at first silt, but sooner or later sand. At first the action may be beneficial, as the good soil from villages higher up is washed down, but soon the sand comes, and this is driven about with the wind, and the good soil is covered and rendered unculturable. The land thus destroyed is called "choh" land. Some 30,000 acres of good land have been spoilt in this way, and remedies have in vain been suggested. The cause assigned is, that the hill sides have been over-grazed, and the trees along the banks of the former streams have been cut away, so that the soil is not held up, and the streams, no longer confined to their course, have spread over the country. The apparently most reasonable suggestion made is to close the hill wastes to grazing, and to let the sides clothe themselves again with grass, shrubs, and trees. There are, however, difficulties in the way of dealing with the "chohs" under Chapter III. of the Indian Forest Act, the Government not caring to risk the responsibility of having to acquire the land (as they might be called on to do) some 10 or 12 years hence at fabulous prices.

Land infested with *kans* grass and *kunda.*

72. The infestation of land with *kans* grass (*Saccharum spontaneum*), with *kunda* (*Saccharum ciliare*), and other deep-rooted and fast-spreading weeds, is a matter for which there are remedies in deep and continuous cultivation and stirring of the soil, also by heavy manuring, and by leaving the weeds to rot, as well as by embanking and flooding the land with water. But, unless these steps be taken in hand early, the evil may rapidly increase, and the land be pronounced unculturable. Mr. Gollan, the Superintendent of the Saharanpur Botanical Gardens, pointed out to me the grass in the Municipal Gardens, Saharanpur; it is now a mass of *dúb* grass (*Cynodon Dactylon*), but had at first been infested with *kans*. By manuring the land heavily with night-soil and town refuse the *kans* grass had disappeared entirely. Mr. Gollan believes that this can be effected in a single season, and he instanced to me that the same thing had been done at Wingfield Park, Lucknow.

I have myself seen, in the Central Provinces, land that was within quite recent times under cultivation, but which has been abandoned on account of the *kans* grass. I learnt that the rent had been remitted on this account, but I could not help thinking that had the *raiyats* been obliged to cultivate their fields diligently, as they would have been, for example, in the congested districts of the North-West Provinces, the *kans* grass would soon have been eradicated. A North-West *raiyat* would have quickly been down on hands and knees and never have let the weed get the mastery. Here, on the contrary, amid easier surroundings, not only was the cultivation less careful, but as each field was in turn abandoned the weed spread, and its seed was carried on to the neighbouring plots, while the tenant who should have eradicated it at the beginning, rejoiced in the remittance of his rent. It may seem a hard thing to say, but I fully think that, in cases such as this, the improvement of the soil will be mainly effected by the pressure of circumstances necessitating a better and more careful cultivation.

In the Madras Presidency I saw a quantity of land near Bellary infested with the weed *kunda* (*Saccharum ciliare*), as also near Gadag, and along the Kistna river. The cultivators dig up the weed by hand labour, collect it in heaps and burn it.

Reclamation of saline land (*usar*).

73. Of a different nature to the foregoing is the improvement of saline land or *usar*, a subject on which much good work, energy, and ability have been expended by the Government, and mainly by the Agricultural and the Irrigation Departments of the North-West Provinces.

Extent of *usar* plains in N.W.P.

Usar land, as explained in paragraph 67, is land which is impregnated with soda salts to such an extent as to make it unfit for growing crops. A white "snow," which is made up of these soda salts and is termed *reh*, spreads over the surface of the ground, and cultivation is impossible. Enormous areas, especially in the plains of Northern India, are thus affected, and in the North-West Provinces alone there are between four and five thousand square miles of *usar* land. In the Deccan and in the Southern Mahratta country, too, are similar large tracts. A strange feature is, that, scattered amidst the barren parts are patches here and there where cultivation, and that, too, of a high order, is carried on. Such crops as opium, sugar-cane, wheat, castor-oil plant, and cotton, all of which require a good soil and high cultivation, may be seen on these fertile spots, standing out like oases in the salt-covered desert all around them. How this has come about, whence the salts are derived, whether they are spreading in extent or not, how they may be checked, and how the land may be reclaimed, are questions which have led to many long enquiries and experiments to which I must here refer. Already in 1874 the Irrigation Department of the N. W. P. set about trying to reclaim *usar*, and in 1877 a "Reh" Committee was appointed to investigate the subject, and to determine the lines of future enquiry. Subsequently, experiments were commenced at Awa in 1879, at Cawnpore in 1882,

The "Reh" Committee, 1877.

and at Aligarh in 1885. Most of these being still in progress, I was enabled to visit them and see what had been done.

The origin of *reh.*

74. Naturally, the first question for the "Reh" Committee was, to say what *reh* was, and whence it came. Its composition, as explained in paragraph 67, is variable, but soda salts are always the main ingredients, the carbonate of soda preponderating generally, at other times the sulphate of soda; common salt and salts of magnesia and lime occur likewise. What accounts for the preponderance of one salt or the other on any particular area has not yet been shown. Different views have been propounded as to how the soda salts originated.

Professor Medlicott's views.

Professor Medlicott, who was a member of the "Reh" Committee, held that *reh* was the result of the decomposition, by air and water, of rock minerals found in the soil, and that they were those parts unassimilated by vegetation, and which were not removed by rain water. He was, further, of opinion that the upper layers of the soil were originally quite free from salt, but that consequent upon the destruction of forests and the extreme climatic conditions that followed, aided by the introduction of canal irrigation, the salt was first dissolved and then brought to the surface. Professor Medlicott, relying upon one or two analyses made at his instigation, regarded the canals themselves as bringing a considerable amount of salt, and expressed himself strongly to the effect that where canal irrigation came, there must, in a few generations, be complete destruction by *reh*. In his view, *reh*, accordingly, was saline subsoil water.

Sir Edward Buck's views.

Other opinions found expression in the "Reh" Committee, Sir Edward Buck attributing the appearance of *reh* to the presence of a series of depressions, the salt from the higher parts getting washed into the depressions by the first shower of rain; thus the higher portions might become culturable, and the depressions infertile, owing to the *reh*.

Opinions of the "Reh" Committee.

Finally, the Committee came to the general conclusions that *reh* was the result of evaporation in a dry climate; that it would make its appearance if the water-level were raised; that it spread to a limited extent by surface washing; that its occurrence was concurrent with that of an impermeable surface; and that canal water did not itself bring the salt to the land.

Review of the evidence; my own conclusions.

Reviewing the facts brought out, it appears to me that there is not sufficient evidence for believing that the canal water actually brings the salt to the land. The analytical evidence on which the assertion is based is neither strong nor consistent; the amount of solid residue per gallon in some of the analyses of water quoted is about 28 grains, a by no means large amount, while in others it is given as only 11 or 12 grains per gallon. Analyses made by myself of canal water from the Cawnpore branch of the Ganges Canal gave only 15 grains per gallon of solid residue, containing less than 2½ grains of soda salts, while that of water from an adjoining well showed 72 grains per gallon of solid residue and 40 grains of soda salts. One would expect the well water to cause an efflorescence of soda salts rather than the canal water, but this was not the case. Again, if canal water were the real source, it would not, to my mind, explain the fact that the composition of *reh* varies o much, nor why the canal should in one part give rise to *carbonate* of soda, and in another to *sulphate* of soda principally. Nor, if the origin be saline subsoil water, is it altogether made clear to me why *reh* should occur here and there, with culturable patches between. I am much more disposed to consider the *reh* in the light of local deposits, derived undoubtedly from the decomposition of the mineral ingredients of the soil, but collected probably in depressions below the surface, and left as a deposit, just in the same way as a bed of phosphate of lime or similar mineral deposit is formed, or as a bed of sand, of gravel, or of clay, is found. So long as the surface was covered with trees and vegetation there would be less capillary attraction, but with the denudation that ensued would come the "baking" of the surface; where this surface was clay, capillary action would be much increased. Without moisture, however, the salts might remain harmlessly below: but if we now imagine canal irrigation to be introduced, there would be present the two forces requisite to bring the *reh* to the surface, viz., the water to dissolve the salt, and then a strong evaporating force, such as the sun, to beat down on the bare unprotected ground, and to draw the salt-holding water up, this action being aided by the capillarity of the clay topsoil. This appears to me to account for what has been often observed, viz., that *reh* occurs in impermeable clay soils, and but very seldom on sandy soils. I incline, therefore, to the belief that where, amidst *usar*, culturable spots are found, it is either because these are spots where there is no *reh* underlying, or because, on account of the occurrence of a sandy rather than a clayey topsoil, capillary action is not so strong at that particular place. The same result of reducing capillarity would be effected by cultivation, by manuring, or by the growth of trees, shrubs, or grass. The fact that such measures as the above have proved the best in the endeavour to reclaim *usar* land gives considerable reason for believing that their removal has conduced to its existence.

The variableness, not alone of composition, but of the *extent* of the action of *reh*, is another reason for considering its occurrence as *local*, and not as coincident with the distribution of canal water. There is what is called "very bad" *usar*; there is also other which, though salty, may be fairly easily reclaimed, and these are often found in close proximity to one another. How could this be unless the deposits were *local*, *i. e.*, unless there were more salt in some spots than in others? Nor would it be consistent altogether with a theory that attributes its occurrence solely to the incoming of the canal water. Canal water, I have no doubt, supplies one factor necessary to bring *reh* from below to the surface, but I do not at all think that it directly brings the *reh*.

Experiments on reclamation of *usar*.

75. Passing next to the experiments made for the purpose of reclaiming *usar*, I must briefly note these.

Experiments of Irrigation Department, N. W. P., at Aligarh and Etawah.

The Irrigation Department of the N. W. P. began in 1874 by taking up areas in the Aligarh and in the Etawah districts. At Aligarh there are now three areas treated as plantations. The best result was attained by digging holes, 4 feet deep, filling them with canal silt, and then planting *babul* trees (*Acacia arabica*) in them. Canal water is available for watering the trees, and, on the *usar* land between, *dáb* grass (*Eragrostis cynosuroides*) is sown. The grass grows plentifully, but there is no sale for it, and the trees grow well enough till they come to a height of about 20 feet. Then they seem to reach a subsoil of *kankar* (concretionary limestone) and die.

At Etawah there are also three areas, and here the most successful plan has been to embank land and to run canal water and silt over it for about four months. These areas may now be described as reclaimed, as they have been let out for cultivation. Still, it is held that the capitalised value of the improved land has not covered the expenditure.

Experiments of Agricultural Department, N. W. P.

1. At Awa.

In 1879 experiments were begun at Awa by the Agricultural Department of the N. W. P. Here tree-planting was not tried, but only simple enclosure and exclusion of grazing. Although the experiments came to a premature end, owing to the Awa Estate falling out of Government hands, they amply proved that by simple enclosure a plentiful supply of *kar usara* grass (*Sporobolus pallidus*) could be obtained on the very worst *usar*, even that covered by efflorescence. This means, in brief, that, if cattle be kept off and be not allowed to nibble away every blade of grass as it appears, the worst *usar* will rapidly clothe itself with grass of a kind. The difficulty is then what to do with the grass.

2. At Juhi.

Following on these lines, the Agricultural Department started fresh experiments in 1882 at Juhi, and also at Amramau, near Cawnpore. At the former, simple enclosure was adopted for the preservation and extension of the natural grasses, and, on elevated spots, fuel and fodder trees were planted. The grasses have decidedly improved, and the success of the trees has been fair. Since 1888 Mr. Duthie has had selected spots under his observation, to see what changes take place in the herbage. The better grasses, such as *janewa* (*Andropogon annulatus*), *musel* (*Iseilema laxum*), and *anjan* (*Pennisetum cenchroides*), are gradually replacing the original *usar* grass (*Tetrapogon tetrastachys*). At the time of my visit (January 1890) there was a most marked difference between the enclosed land and that outside the boundary, the grass standing knee-deep within it, whereas the other was nearly bare, and mostly covered with *reh*. Here, too, it seems, however, doubtful if a fair interest on the capital expended will be yielded.

3. At Amramau.

At Amramau the experiment was commenced on a commercial basis. Mir Muhammad Husain, the Assistant Director of Agriculture, N. W. P. and Oudh, induced the Government in 1882 to purchase 52 acres of *usar* land at R. 1 per acre. This he enclosed for two to three years, then put dairy cattle and sheep on to eat the grass, and sold the milk off the farm. Next, he embanked fields before the rains came, and so held up the water in them; when it had soaked in, he ploughed and manured the land with the dung of his cattle and sheep, and then sowed rice. If the rice took, a winter crop followed, and this was the test of reclamation. In this way one-half of the farm has already been reclaimed and let at Rs. 8 per acre. The total cost of reclamation has been Rs. 2,000, and this sum Mr. Holderness, the Director of Agriculture, estimates will just be cleared. A pleasing feature is that landlords (*zemindars*) around are beginning to try the experiment themselves. Immense credit is due to Mir Muhammad Husain for the way in which he devised and also carried out this experiment, certainly the most hopeful of any yet attempted in the reclamation of *usar*.

4. At Aligarh.

Meantime, in 1885, further experiments on a large scale were initiated at Gursikran and Chherat, near Aligarh At the former there are 718 acres, and these are treated like the Juhi enclosure, cattle being kept off, and the grasses being left to themselves. Mr. Duthie now has these also under observation. *Kar usara* (*Sporobolus pallidus*) is the principal grass. Enclosure is effected by a small ditch and mound only, but it is quite enough to make a marked difference between the bare plain outside and the enclosed part, in which latter the grass grows thickly. The better grasses, however, are only very slowly replacing the *usar* grasses. In the hollows *dúb* grass (*Cynodon Dactylon*) begins to come.

At Chherat there are 242 acres. One-half is left to itself, like Juhi, and here the better grasses are decidedly taking the place of the *usar* grass (here *Chloris tetrastachys* is the chief *usar* grass), *dúb*, *dáb*, *anjan*, *musel*, and *gandel* (*Andropogon laniger*) being now prominent. Grass came well the first rainy season after enclosure was begun, and now there are but few bare patches left. No manure or irrigation is used. The grass is allowed to die down, and the soil seems to get coated with a covering of vegetable mould, on which subsequently a better kind of grass appears. I had noticed this same at Juhi, and more particularly that there were numerous ant-hills inside the enclosure, but none outside. On these hills were gathered the glumes of the grasses, doubtless adding more vegetable matter to the soil, as well as loosening it. On comparison of notes that had been taken, these ant-hills were found to have moved onwards over the formerly unoccupied space; the ground was in consequence raised where they were, and on these elevations the grass grew in clumps. Sir Edward Buck is of opinion that, by the raising of these mounds, the first flow of water in the rains flows off them and runs into the lower land, taking the salt with it and forming there a strong saline solution which destroys vegetation. Sir Edward thinks that if this first flow could be prevented from spreading over the surface, or be run into catchment holes or channels, it would do no further harm. However this may be, I believe that it is from these raised spots that vegetation begins to spread, and that the increase of vegetable matter on the surface soil is a sign of improvement. I quite agree also with Sir Edward Buck that a certain amount of damage, at least, is done by the surface flow of a saline solution, and that it would, in many cases, be lessened by the raising of a small mound or embankment. On one part of Chherat the experiment has been tried of scraping off the efflorescence as it forms, but this has not been successful, nor has much success as yet attended the efforts to grow the salt-bush (*Artriplex nummularia*), date-palm, or other salt-loving plants, in the hope of extracting the salt from the soil. But one-half of Chherat has been more recently worked on the lines of Amramau, and different methods of reclamation have been tried. Thus, 35 acres, on which the salt was two to three inches thick, were surrounded with an embankment, and the rain water was thus kept in to the depth of three feet. Subsequently the land was ploughed to loosen it, and when I saw the place the grasses were being fed off by cattle. It was noticeable that the *usar* grass was nearly all gone. Mir Muhammad Husain had observed that it rotted away in the stagnant places, and this led him to try flooding the land. Here, anyhow, it disappeared, and the first grass to take its place was *narri* (*Diplachne fusca*); this, starting from a point a little raised above the rest, spread its runners in every direction, looking just like a catherine-wheel; the runners in turn rooted themselves in the soil and became fresh centres. After seeing this, I could well understand that simple enclosure could enable the grass to establish itself and to cover the surface, whereas, if grazing were permitted, the young shoots would be at once nibbled off, and never be allowed to spread. *Anjan*, *dúb*, and *dáb* also in turn appeared. Yet another portion has been flooded from the canal, and the water held up by embankment; reclamation has gone so far that some of the land has been let out to cultivators, and I saw wheat crops growing on it here and there. Enquiring of a *raiyat* which land he would like to have if more could be let to him, he said that what he liked was the "black" soil (doubtless that which had the vegetable crust to which I have referred), I then asked him to indicate what part of that now growing grass could be cultivated and what not. He darted off at once to where *dúb* grass was, and said that was what he would like to have, but not that which had the *usar* grass on it.

Another plan of reclamation tried has been that of manuring heavily with night-soil.

5. At Naraianpur by use of night-soil.

At Naraianpur, near Cawnpore, Mir Muhammad Husain took up 10 acres of *usar* land four years ago, and trenched night-soil in it before the rains. Mounds were put round, and the rain water held up. After 10 months the land was let to a cultivator for Rs. 20, and Rs. 40 was offered if a lease for six years were granted. Here canal water was available. Of this land there were 800 acres in the neighbourhood.

6. At Dera Ismail Khan with night-soil.

Again, at Dera Ismail Khan it was found that the "Ottley" plan (digging out the soil to a depth of about 18 inches, spreading night-soil in the pit 9 inches thick, then sifting the earth back and levelling the whole, subsequently watering it) got rid of the *kalar* or saline efflorescence.

Lastly, I have to instance other attempts to deal with *usar* land by growing trees upon it. In the cases given so far the success has not been a marked one, though it has been shown that they will grow, as also grass in abundance, if enclosure be resorted to.

7. At Kapurthala by growing dhák trees.

In the Kapurthala State there are 9,000 acres of land in Phagwara *tahsil* which have been taken up by the Administration. Of this, 7,660 acres are so much impregnated with *kalar*, or soda salts, that they are not fit for cultivation. Nevertheless it has been found that the *dhák* tree (*Butea frondosa*) flourishes on this soil, and 40,000 maunds of fuel (maund = 28 lbs. here) are supplied from one plantation annually. Every 10 years the whole is cut over once, and the sale proceeds and grazing fees amount to Rs. 9,000 per annum, while the yearly expenditure by the State is only Rs. 540. There is this advantage with *dhák*, that cattle, sheep, and goats will not touch it, and so grazing does no injury. I notice that the *dhák* tree has been but little tried in other experiments; it should, I think, be more extensively grown on *usar* land, and there seems to be no reason why the Kapurthala plan should not succeed elsewhere.

Summary of experimental work on *usar* reclamation, and my general conclusions.

76. To summarise the experimental work done on the reclamation of *usar*. It seems thoroughly established, Firstly, that by simple enclosure and exclusion of grazing, grass (probably *usar* grass only at first) will establish itself, and cover even the worst places; that the grasses will slowly improve, and trees may be fairly successful. Secondly, that by covering *usar* land with a thick coating of canal silt, and then flooding it (as is done in Egypt), it may also be reclaimed. Thirdly, that by enclosure, feeding off the grass, embanking the land, allowing the rain water to be held up on it, then ploughing and manuring it, it can be rendered culturable. Fourthly, that the same may be done by heavy manuring with night-soil, where water is procurable. There are difficulties to be encountered in every case, such as that of disposing of the grass grown; then canal water and canal silt are not everywhere available, nor is there sufficient night-soil or other manure to warrant the outlay involved in reclaiming. But it seems to me that the plan of embankment and holding the water up, as well as manuring the land with stock put on it, is feasible everywhere. Where silt-laden canals are at hand, they could be run on to the land, for they would be in a silt-laden condition just at the time of the rains, when they are not so much needed for the irrigation of cultivated land. As to the grass difficulty, this might be overcome by making the grass into silage. The difficulty with haymaking is that the grasses that grow often come during the rainy season, when they cannot always be made into hay, but if made into silage, simply stored in pits dug in the ground, they might afford abundant succulent fodder for cattle. Lastly, where trees are grown, the best plan is to have a rapid succession of quickly-growing trees or scrub, rather than to try and obtain trees of any good size; the *dhák* tree (*Butea frondosa*), as at Kapurthala, should also be much more extensively tried.

Suggestions have been made in the past that subsoil drainage will be found the only way to cure *usar*, but I can hardly look upon this as a practicable remedy in India.

Taking what I have seen, both of the occurrence of *usar* land and the attempts made to reclaim it, I believe it to be concurrent with the existence of an impermeable condition of the soil, conducing (as clay does) to increased capillary action; and that improvement of such soil will be effected by any means which tend to alter this impermeable condition, either by forming a fresh and lighter surface, such as is done by the finely-divided canal silt, or by breaking it up, as is done by the growth of grass or trees, or by manuring and ploughing. The formation of vegetable matter on the surface is, I believe, most important, and the covering of the soil with grass tends to decrease that "baking" of it which, as we have seen, is one of the most powerful agencies at work in causing *reh* to appear.

A good deal has been said, notably by Mr. Holderness, the Director of Agriculture for the North-West Provinces and Oudh, as to the result of the experiments not having been a financial success on the whole. To my mind a great deal too much has been made of this aspect; not that it is not the ultimate test of success, but because it should be remembered that until the effort has emerged from the experimental stage it cannot be fairly put upon its trial. So long as experiments are being tried, expenditure is made upon a great many things which have to be abandoned later on; experiment should be for the purpose of seeing *which one* of a number of different plans that have suggested themselves seems to give the *best prospect* of success, but not until this has been reached can the system itself be fairly said to be on its trial. It is a remarkably promising omen that Mr. Husain has been able to show, even in the initial stage, such success as has been attained at Amramau, and to him very great credit is due.

Not long ago it would have been said that *usar* could not be reclaimed at all, and to show that it can be is, in itself, a most valuable fact. That it may not at present *pay* to take up *usar* land and so reclaim it, is a matter affected by present conditions; but there may come, ere long, a demand on the soil, owing to pressure of population and spread of cultivation, which may call for even *usar* land to be taken up, and then it may pay well to reclaim it. The experience gathered from past experiments will then supply the necessary guide, and a financial success may well result.

Reclamation of waste land must be mainly the work of Government.

77. The reclamation of land, whether it be ravine land or *usar* land, must, as indicated in the foregoing pages, come mainly from Government agency. In a few instances the native proprietors may follow an example set, but the initiative must come from Government, and from Agricultural Departments in particular. The improvement of land infested with *kans* grass and other weeds is part of a better and more careful cultivation.

The need for an Agricultural Chemist.

78. In reference to the reclamation of *usar* I have expressed my surprise at this enquiry having been carried out without the help of an Agricultural Chemist. Such a man would have been able to render very considerable help, and to have prevented many mistakes and speculations from being made. To take a single instance—when remedial measures were attempted it should certainly have been ascertained (as could have been done readily by chemical analysis,) what amount of salt was present originally in the soil, and how much salt each remedial process had succeeded, in the end, in removing. It is still unknown in what quantity the salt exists, and in what amount it will be injurious. Such an example as this constitutes a strong claim for having agricultural investigation in India carried out with the association of an Agricultural Chemist. I do not say that the presence of such a man would, of itself, enable the *reh* question to be solved, but I am sure it would very greatly aid the enquiry, and no such enquiry should be carried out without the assistance of an Agricultural Chemist.

CONCLUSIONS.

CONCLUSIONS.

79. The differences which are directly traceable to the varying nature of soil are, like those resulting from climate, not capable of elimination either by the people or by the Government; they can only be modified to a certain extent. Any improvement of agriculture in this connection will be achieved by—

(1) increasing, in dry tracts, the supply of water and, consequently, of moisture to the soil;
(2) increasing the manure supply and enriching the poorer soil;
(3) experimental enquiry and the scientific study of soils and their treatment.

The main work of the above must fall upon Government; for the people will only in a few cases at best follow the initiative set, nor indeed will they have the means for so doing. The third part, or the introduction of Western Science, must also come from Government alone. Of scientific study of soils in India there has been almost a total absence in the past, and experimental work, as in the reclamation of *usar*, has suffered in consequence. I regard the problem of the possible exhaustion of the soil, under a continuation of the present system of agriculture, as one which the Government will have to meet by devising measures for increasing the manure supply of the country. Good work has been done by the Agricultural and Irrigation Departments of the North-West Provinces in the endeavour to utilise ravine land and to reclaim *usar* land, and encouragement should be given to the continuance of this work of enquiry.

RECOMMENDATIONS.

RECOMMENDATIONS.

80. I recommend:—

The increase, by means of Irrigation, of the water supply to dry tracts.

The increase of the manure supply to the soil.

The instituting of Enquiry to ascertain where such measures are needed and can be carried out.

The continuation of Experimental Research, aided by Chemical Science.

CHAPTER VI.

WATER.

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WATER.

81. WATER, in one form or another, is indispensable to agriculture, and in no country does this relation acquire greater significance than in India. So varied, however, are the climatic conditions met with in different parts, that each must be considered by itself before any general conclusion can be arrived at as to the sufficiency of the rainfall or the need of supplementing it. Not only climatic but geological features also will determine the need and the mode of further supply. This supplementing of the natural rainfall may, broadly, be called Irrigation. In this sense we may consider India as divided into three great areas :—

General division of India in reference to irrigation requirements.

1st. Where irrigation is *not needed.*
2nd. Where irrigation is *highly desirable.*
3rd. Where irrigation is *absolutely necessary.*

Division into "protected" and "precarious" tracts.

82. The *first* division comprises districts where there is an abundant rainfall; these are protected thereby from drought and famine; such regions exist over Burmah, Assam, Eastern Bengal, along the sub-Himalayan range, and in the Western Ghâts. In the Central Provinces also, and over a great part of Central India, a sufficiency of rainfall is aided by the presence of a black soil which retains that water firmly, and to which the supply of irrigation would possibly be even harmful.

The *third* division comprises the driest tracts of all, the regions of lowest rainfall, such as the arid plains of parts of the Punjab and Rájputana, with nearly the whole of Sind. In these, while irrigation is an absolute necessity for the carrying on of agriculture, yet in respect of being subject to famine they are safer than those of the *second* division, this latter including all those districts where the rainfall is uncertain and variable. The reason of this, as explained in Chapter IV. paragraph 34, is, that where rainfall is low the *raiyat* or cultivator will never try to grow a crop unless he has a certainty of water, whereas, in parts to which sometimes rain comes in sufficiency and sometimes not, he is tempted to risk the growing of a crop, and should the rain then fail, the crop may be entirely lost. It is these districts of uncertain rainfall that are the really "precarious" ones, and here the fear of famine is almost ever present. They are the tracts which are light-coloured on the Rainfall Map, and they extend over a great part of North-West India, Rájputana, the Deccan, and Madras. It is to providing protection against famine in these precarious tracts that Government have devoted such constant efforts, and that so much skill has been exercised by the Irrigation Department in particular.

Precarious Districts indicated on Rainfall Map.

Summary of main types of water-supply and their distribution.

83. It is well now to summarise the main types of water supply met with in India, and, after that, to show how irrigation alters in character and how its extension is largely dependent upon the physical conditions and geological features of the country.

(*a*) Rainfall.

(*a*) In the first place is the *Rainfall*; abundant reference has been already made to this in Chapter IV. (Climate). The *dark-coloured* parts on the Rainfall Map are those of heavy rain, and are thus naturally protected from drought. Under the same heading has been mentioned the water-retaining black cotton-soil, where, too, irrigation is not called for. This soil covers the parts coloured *green* on the Geological Map,

The above districts may be considered as "protected," and as not requiring further irrigation.

(*b*) Inundation by rivers and streams.

(*b*) After this we may take those districts which do not require irrigation because they are *inundated* by rivers, or which, though not inundated, yet derive sufficient moisture from rivers in their proximity. Instances of the latter have been given in the tracts along river beds in the Punjab. Inundated tracts are found also in many parts of the Punjab, for instance, at Multan, where the country beside the river banks is often flooded to the extent of six or eight miles. Again, in Gûjrat (Punjab) and other tracts along the foot of the hills there are large areas which are annually inundated by mountain streams bringing silt down with them. The rainfall is insufficient for the crops, and the spring-level is too deep for irrigation wells, so the flood waters of the torrents that issue from the hills are turned out of the beds of the torrents by means of temporary dams erected in the beds, and are thus poured on to the slope of the country. The latter thus acquires sufficient moisture and also a renewal of silt more than equivalent to a manuring. An instance of a dry tract such as this is Shahpur, between the Indus and the Jhelum.

(*c*) Canals and river-channels.

(*c*) Next are the canals :—

These may be classed under three heads :—(1) The *perennial canals from snow-fed rivers*, found, for instance, in Northern India. (2) *Inundation canals*, available only while the river is in flood. The banks of the river are above the level of the surrounding country and the flood waters are carried off from the river. This is, accordingly, a rainy-season supply only. Such canals are met with in the Southern Punjab and in Sind. (3) *Canals* or rather *channels from rivers that are* *not snow-fed.* A dam, or "anicut" as it is technically known, is thrown across the bed of a river, and the latter is turned into a lake, from which it is led into irrigating canals and distributing channels. In this way an autumn and winter supply is obtained. Of this nature are the channels off the Cauveri, the Godaveri, and the Kistna rivers, in Madras.

(*d*) Wells.

(*d*) The next system is that of wells, the most widely-distributed one, but seen principally in the alluvial belt of the Ganges plain, and notably in the Doab (or *two-river* district, *i. e.*, the country lying between the two rivers, the Ganges and the Jumna).

(*e*) "Tanks."

(*e*) Then follow the so-called "*Tanks,*" principally found in Madras, where the ground is rocky and the country hilly or undulating. These are really lakes or reservoirs, and are constructed by putting dams across depressions or valleys. In them rain water is collected for use in the dry season. Some are also fed by jungle streams and rivers as well as by rain water. They occur, further, in Rájputana and in Central India.

(*f*) Shallow tanks or ponds.

(*f*) Lastly come the *shallow tanks or ponds* which are dug in the earth whenever the soil is of a clayey character, and serve to hold the one year's supply of rain water. These ponds are met with in Western Bengal, the valley of the Ganges, as also in Madras.

Distribution of systems of irrigation according to the physical features of the country.

Geological Map.

84. On referring to the Geological Map, sufficient reason will be found for the occurrence of the particular systems in each part, the alluvial soil of the north (coloured *brown* on the map) lending itself rather to canals, wells, and shallow ponds, and the rocky ground of Madras (coloured *red* on the map) to the so-called "tanks," as well as to channels, whilst the central, or black cotton-soil portion (the part coloured *green*) needs neither particularly. But the variations of rainfall, situation, and nature of soil, in different parts call for still further consideration. Thus, to take the alluvial plain of the Ganges—in the extreme west the water lies too deep down for wells, and this part, including the Punjab generally, is essentially the region for *canals*; the central part, the North-West Provinces, is the *well* district *par excellence,* though supplemented here and there by canals; then, coming to Bengal,— in the western portion are *shallow ponds* or tanks, and mainly where clay covering the soil enables the water to be retained, whilst in the eastern portion the rainfall itself is enough, and canals would be out of place and even do harm. In Madras the underlying rock, on the contrary, lends itself more naturally to the construction of large reservoirs or "*tanks,*" holding more than the one year's rainfall. But this is not all, for, as is well illustrated in the North-West

Provinces, a cross section may be drawn through the Gangetic plain, and it will exhibit different features of irrigation in each division. Thus, taking such a cross section, we may have, first of all, a region like the sub-Himalayan range, where rainfall is abundant and no irrigation is called for. Then there will come one where, with less rainfall, the water lies close below the surface, and can be easily obtained from shallow wells of, say, 10–20 feet depth. This is the case, for instance, at Bareilly. Next may be one where the water lies deeper and is less readily obtainable, and canals may be called for in addition. Such is found to be the case in the Doab, where wells are 20–30 feet deep. Lastly, may come a region situated on a central elevated ridge of the country where the wells are too deep to be profitably worked; the water is often brackish, and canals are the only available means of irrigation. This is the case along the Jumna river, the wells being 30 feet deep or more, and the water bad.

I have set these points out, because without bearing them in mind it is not possible to understand the considerations that have to be taken into account in providing for the irrigation of any tract, nor yet to grasp the point of what I wish particularly to impress, viz., the necessity of careful enquiry into the agricultural requirements of each separate district and the best way of supplying these.

The great work done by the Government and the Irrigation Department.

85. Before dealing with particular points connected with each class of irrigation, in the endeavour to show where improvement may possibly be effected, I wish to qualify any suggestion I may make, by saying, at the outset, that I consider the way in which Government have attacked the problem of irrigation and the manner in which the Irrigation Department have carried out the work, are worthy of the highest praise; moreover, the disposition of each to meet, wherever it is practicable, the needs of the country, both for protective purposes and for the improvement of its agriculture, shows how deeply concerned they are in the well-being of the people.

Easy though it be to criticise Government Departments, be they Irrigation, or Forest, or Agricultural, and to point to mistakes that have been made in the past, and to isolated cases where harm rather than good has resulted, I prefer, and think it is but right, to acknowledge the vast work done and the enormous benefit that has accrued to the country generally as the result of the attention which Government have bestowed on this great subject of Irrigation. It is hardly necessary even to ask that the operations should be extended, for both Government and the Irrigation Department are fully alive to the necessities, and will not fail to avail themselves of every opportunity for extension of their work.

Perennial Canals.

86. *Perennial Canals.*—It has been explained that in certain parts, for instance, the Western Punjab, the rainfall

Changes produced in the appearance of the country by the introduction of a canal into a district.

The Sidhnai Canal)

is very meagre, and the water-level is so low that wells cannot be sunk profitably; hence the canals from snow-fed rivers are the only means of irrigation. I cannot give a better instance of the change effected by the introduction of a canal to a dry arid tract, than what I saw in the course of my tour through the country lying around Multan in the Punjab. The Sidhnai Canal has been brought here, and now, wherever it spreads its arms, fertility and prosperity abound, whilst the parts which lie beyond its influence are typical of barrenness and desert. Here a complete transformation in the appearance of the country has been effected. The soil, though in itself rich enough, is powerless, in the absence of water, to sustain its crops. It is only where an occasional well occurs, or where water has lodged in a depression, that there is any cultivation at all; but where the water can reach, agriculture flourishes. On one side of the railway line, as I travelled from Multan to Rashida, the Sidhnai Canal spread, and cultivation was all around; on the other side of the line there was no canal, and the land was entirely bare, save for a few stunted bushes. No one could see the contrast presented, without being deeply impressed by the great good done by canal irrigation. This scheme was started in order to take settlers from the congested districts of the Punjab (Lahore, Amritsar, &c.). It was estimated that 64,000 acres of land would be required, but already 110,000 acres have been let to cultivators, so that the canal has been very successful. Other instances which particularly struck my attention, as exemplifying the beneficial effects of canals upon agriculture, were the remarkable development of market-gardening around Amritsar (Punjab), the outcome of the Bari-Doab canal; the sugar-cane and rice cultivation at Hospet (Madras), which has entirely developed since a channel was taken off from the River Tungabadra; and the sugar-cane cultivation around Poona.

Primary use of canals.

When speaking of wells I shall have occasion to point out respects in which I consider that cultivation by means of them is superior to cultivation by canal, but it is necessary to point out that it is only in a very limited region, mainly the Doab, that the two systems really come into competition. What is requisite in extending canals is, to take them primarily to those districts which have no other available means of water supply, but not to supplant an existing cultivation carried on by means of wells or tanks. But where these latter means are insufficient, then canals may do a great work in supplementing the supply. The main object should, however, be to carry canals to the parts where agriculture must depend upon them alone.

Objections urged against canals.

87. It has been urged against canals, and with some reason, that in some cases they have been brought where they were never needed; that they have been carried across the main drainage lines of the country, and have obstructed the natural drainage, besides raising the water-level, causing the spread of the saline efflorescence known as *reh*, spoiling the wells, and bringing fever and ill-health to the population affected. There have been, and always will be, minor complaints of the occasional harshness of higher, and the corruption of inferior, canal officers. But, to my mind, all these objections sink into insignificance before the grand work that has been done, and that is now being carried on in the light of the experience of the past. Were but the cultivators to use the water with anything like the care with which it has been provided to them, the results would be much greater still. The Irrigation Department will, I know, not be slow to acknowledge that there have been mistakes in the past—mistakes of construction and of distribution—but they are now careful to avoid these as far as possible, and when extension of canals is made, it is only after the agricultural circumstances and needs of the districts have been considered, in order to determine whether they ought to be served by canals or by wells, and in order to construct the canals so as to give distribution of water over the widest area possible.

Canals have been taken where not required.

88. I will now consider the several objections taken to canals. The first is, that canals have been carried where there was no need of them. A colour is given to this objection because, in order to reach tracts where there is no other means of water supply, canals have sometimes to pass through districts already provided for; still, it is quite true that canals have been brought unnecessarily to some parts of the country. In the Cawnpore district of the North-West Provinces there are many villages along the line of the canal, like Rura, which ought to have depended upon wells, and indeed were partly supplied with them; but now only the ruined remains of the wells exist, for they were merely dug in the ground, and had no masonry to support the sides, consequently they fell in when the water-level was raised through the introduction of the canal. That this is altogether due to the canal is hardly the case. I made special enquiries on this point, and found that though destruction of wells undoubtedly occurred at first, yet the water-level soon became constant, and wells can now be easily made without masonry. What really happened was, that when the canal came the cultivators relied entirely on it as the easiest means of watering their fields, and so they used the water wastefully, and allowed the wells to fall into disrepair. It is only when the supply of water runs short, owing to the spread of irrigation over a wider area, that the *raiyat* begins to get economical in the use of canal water. In some instances, indeed, the canals have improved the wells by raising the water-level and making the supply more accessible. Still, there is undoubtedly some reason for complaint that canals have been carried where they were not required. An instance of this is seen in Orissa, where a canal was started in 1866 as a protective measure, after the famine that occurred there, but it has never been wanted since, and has not only been unremunerative, but has also done positive

Instances.

harm to the country by interrupting the natural drainage. The upper part of the Western Jumna Canal is, similarly, not a success. Both in Behar and in the Bombay Presidency there are canals which, in so far as they have not paid directly for their construction, have been called "failures." But this is not a fair view of looking at the question, and no one who has had experience of the loss of human life and of cattle in past times of scarcity, and will contrast it with the protection afforded by the canals now, can for a moment doubt the wisdom of constructing these very canals, although the expenditure may not have been directly recouped. Nevertheless, in districts where wells can quite readily be dug, their extension rather than the replacement of them by canals should be sought. In the Cawnpore district I have seen the wealthier cultivators constructing masonry wells although they had the canal flowing past their land. They were, however, situated near the termination of the canal, and knew that the supply of water was precarious because of so much being used higher up the stream. But on their wells they could always rely, and so they preferred to dig them rather than to trust to the canal.

Construction of reservoirs at termination of canals.

89. In districts situated near the termination of a canal, and where consequently the supply of water must be uncertain, it is worth considering whether reservoirs might not be advantageously constructed which would serve as storage tanks for irrigation purposes. At Cawnpore, during the hot season, I saw the crops of some Káchhi cultivators which were being quite ruined owing to want of water, for, although the canal was within a stone's throw, and water was passing down it, there was not sufficient water to allow of the outlet to the cultivators' fields being opened; nevertheless, the stream, then flowing two feet deep, shortly afterwards found its way again into the river, and its benefit was lost to the land. Had there been a reservoir at the end of the canal, or some system of small tanks in the fields themselves, which could be filled and drawn from as required, less entire dependence could have been placed upon the uncertain canal supply.

Canals have interfered with the natural drainage, and caused ill-health to population.

90. The second objection urged against canals is, that they have interfered with the natural drainage of the country, and that, by raising the water-level, they have brought fever and ill-health to the people. This, again, is a charge which has much to support it; but the Irrigation Department is fully alive to the necessity of avoiding these evils in the future; accordingly, new canals are now aligned with greater care. Villages in the Etah and Cawnpore districts of the North-West Provinces, others in the Delhi and Karnal districts, as also some along the Bari-Doab Canal in the Punjab, are known to have suffered from excessive canal irrigation, and to have become unhealthy on account of the faulty construction of canals, and a reduction of assessment has, in consequence, had to be granted. This subject opens up a very serious problem for consideration. Are the people to have the land left dry, and the climate healthy, though they themselves may suffer and die from the inroads of famine, or are they to reap an

The problem of canal irrigation.

abundant harvest at the sacrifice of health? In other words, are they to drop off one by one by slow degrees and unnoticed, or are they to be swept away in numbers at a time by famine? This is, to put it plainly, the position that has to be faced. The verdict, it seems to me, must be the one that actuated the appointment of a Famine Commission, and also their subsequent recommendation that, the preservation of the lives of the people being the chief concern, the causes which stand out most markedly as sweeping the population away wholesale must be first combated. Beyond this, the only possible line of action seems to me to be the exercise of greater care in future alignment of canals, and the introduction of subsoil drainage in especially bad tracts. Subsoil drainage is, I am aware, a very difficult and costly matter in India, and for the purpose of merely *reclaiming salty land (usar)* is hardly to be thought of; but where the lives of the people are concerned, and when there is undoubted evidence of the depopulation of water-logged districts, I do not see how the issue can be long delayed. At all events, I think that subsoil drainage should be thoroughly put to the trial, in order to ascertain whether it can be carried out successfully on a large scale.

Subsoil drainage as a remedy.

91. Other objections to canal irrigation follow as consequences of the two main ones already noticed. It has been mentioned that the introduction of canals has been detrimental to existing wells. But it is urged also against them that they have caused the spread of the salty efflorescence termed *reh* (*see* paragraphs 67 and 74), in districts watered by canals. I endeavoured in the last chapter (paragraph 74). to explain the part which canals play in the production of *reh*, and to show that they supply the water necessary to dissolve the salts that lie below the surface and enable them to be brought to the surface by capillary attraction. I have pointed out, however, that, by flooding the affected land with silt-laden canal water, a remedy can be provided, and the injured land be practically reclaimed by means of the canal.

Other objections against canals.

Spread of *reh*, &c.

92. *Inundation Canals.*—In the Gangetic system (to which the perennial canals just described belong) the water of the dry and rainless season is utilised. There is then little or no silt, and the water serves rather as a substitute for rain than as a fertiliser. In the case of the Inundation Canals, on the other hand, the silt-laden waters of the rivers are carried at flood time to the higher lands, and thus afford greater benefit to districts where rainfall is deficient. As their name indicates, Inundation Canals are of use only in the rainy season, and they are taken off from rivers the banks of which are above the level of the surrounding country. Such canals are met with principally in the Punjab and in Sind. This system was in vogue before the time of the English occupation of India, and many of the canals were constructed and worked by the Natives themselves.

Inundation canals.

93. *Canals or River-Channels from Spring-fed Rivers.*—These occur principally in Southern India, and do not differ except in their origin and methods of construction and distribution from the afore-named snow-fed canals. It has

River-channels from spring-fed rivers.

Possibility of storing water from rivers before flowing into sea.

been often pointed out that a great deal of water is allowed to flow down the rivers of Southern India and to find its way into the sea, whereas increased means of intercepting it before it reached the sea would result in a large amount of water being saved for irrigation purposes. Mr. Nicholson, in his "Manual of Coimbatore," points out that much good might be done by storing the water of great rivers in reservoirs, and that it would not only supply irrigation, but would prevent a source of danger to the districts below, which arises from the sudden rushing down of the river at the beginning of flood time. In a Report on the Condition of Anantapur Mr. Nicholson instances that the water of the Pennér and the Hagari rivers might be advantageously stored in this way, especially as the districts through which these rivers flow are peculiarly exposed to drought.

"Tanks."

94. *Tanks.*—This term, as applied to the rain, stream, and river fed reservoirs which occur principally in Madras and in Central India, is an incorrect one. They are in reality Lakes or Reservoirs formed by the erection of dams across depressions or valleys, and are fed either by the rainfall or by jungle streams and rivers. They are largely utilised in Madras for rice cultivation, and it is certain that a very excessive quantity of water is often used from them. I noticed this particularly at Salem. Mr. Nicholson reckoned that in Coimbatore as much as 12 feet depth of water in a season was used from tanks kept for rice cultivation. Frequently the tanks are the property of individuals or communities, and are managed by them. In some cases, however, the Irrigation Department undertakes the distribution of the water. Better management in the repair of tanks is a matter calling for attention, and will be referred to later. The supply of water from tanks which are merely rain-fed must, at best, be looked on as precarious, owing to the uncertainty of the rainfall. Tank irrigation is, however, preferred to any other for rice cultivation, but a cultivator will not begin to use a tank unless he knows that there is sufficient water in it to last him for his crop throughout its whole growth. If the tank be full, he grows rice; if it is not, he grows other crops. The consequence of waiting is that a good deal of water is wasted by percolation, and the tank may, after all, not be available. It is difficult to suggest any remedy.

Waste of water in rice cultivation.

Cultivation by tank irrigation.

Though tanks occur mostly in Southern India, yet they are sometimes made in the rice-growing districts of Bengal; or else reservoirs are formed by throwing embankments across drainage hollows or natural slopes of fields, and are used for irrigating rice in the event of long droughts; when required, the banks are cut and the water is allowed to flow out. Reports from Chota Nagpur show that while in some parts, Palamau for instance, irrigation by these reservoirs is a necessity for rice, in others, such as Lohardaga, only a few tanks exist. More might, however, be easily made and the rice be irrigated. On occasions when drought has occurred, the villages that possessed embanked reservoirs have suffered no loss of rice;

once at Banda, for example, the banks were cut, the water was led for four miles, and over 200 acres of rice were thus saved. Even in the Central Provinces it is now under consideration whether in parts, such as the Mandla and Balaghat districts, tanks should not be constructed for rice irrigation.

Shallow tanks or ponds.

95. *Shallow Tanks or Ponds.*—These are the true Tanks, for they are excavated reservoirs, and are not merely those formed by embanking depressions or valleys, thereby holding up the water that comes. The true tanks only hold the rainfall of the year, and dry up entirely in the hot weather. Where the soil is clayey underneath is the most favourable spot for their construction; if the soil be sandy, without clay beneath, the water will soon sink in and disappear. They are, of course, simply rain-fed, and are met with not only in the alluvial soil of Bengal and the Gangetic Valley, but also in parts of Bombay and Madras.

Wells.

96. *Wells.*—I have left the consideration of wells until now, so that I may include under this head some of the principal differences that occur between cultivation by wells and that under other means of irrigation. Irrigation by wells is at once the most widely-distributed system, and also the one productive of the finest examples of careful cultivation. I may fairly say that nothing in the agriculture of India impressed me so much as the excellence of the cultivation carried on by irrigation from wells (" garden ' 'land). This was not the case merely in one or two parts only, but in almost every instance where this system of cultivation was adopted.

Excellence of "garden" cultivation.

Examples of "garden" cultivation

Whether it be in the *betel* and plantain gardens of Máhim (Bombay), the market-gardening of Meerut (North-West Provinces), the "garden" land of Coimbatore in Madras, or that of Gújrat and Hoshiarpur in the Punjab, the finest cultivation I have seen has almost invariably been that carried on by well irrigation. Here it is that the greatest care is given, and the greatest economy used; it is for this land that manure is most saved, and from it every weed is plucked away as an intruder; here every inch is utilised for growing crops—not one crop alone, but often three or even four together—and to these crops the precious water is dealt out, as it were, by measure. To take a single instance:—at Máhim the *betel* plant is watered every sixth day until manure is applied to it, and, after that every third day until the rains come; sugar-cane once every six days until the rains; plantains similarly, and ginger at intervals of three days only. The explanation of the excellence of cultivation as carried on by irrigation from wells is found chiefly in the fact that every drop of water has to be raised by the *raiyat's* labour and that of his bullocks, and that the well itself has often been built with his own money and by his own hands. But I must not dwell on this except to say in regard to this cultivation that I can suggest nothing in it to improve; indeed, the people have mastered thoroughly all details of the system. English farmers may well join with me and look on in admiration, and

Little or nothing to improve in this respect.

it should be the aim of every one interested in agricultural improvement in India to extend this method of irrigation in every way possible.

Ingenious devices of the native cultivators for raising water.

Further, as regards wells, one cannot help being struck by the skill with which a supply of water is first found by the native cultivator; then by the construction of the wells, the kinds of wells, and their suitability to the surroundings and means of the people; also by the various devices for raising water, each of which has a distinct reason for its adoption. All these are most interesting points with which I am not called on to deal, for I see little to improve in them which the cultivator does not know perfectly well. I would, however, draw attention to Major Clibborn's valuable Report on the Construction of Wells in the North-West Provinces, where many particulars as to wells and well irrigation can be found.

Comparison of cultivation by well or canal.

97. As I have explained before, it is only exceptionally that cultivation by means of wells can be brought into comparison with that by canal irrigation, and it must be remembered that the value of the latter system consists in the fact that canals can often be brought where construction of wells is impossible. Where the two systems exist near one another I have sometimes had the opportunity of comparing them. Such was the case at Amritsar, Cawnpore, and elsewhere; frequently, too, wells are used, as at Multan, to supplement the canal supply and to ensure the safety of the crops. Not only are the plots on well (or "garden") land kept very much freer from weeds, but infinitely more care is taken with the distribution of well water than of canal water, except, possibly, when the latter has to be raised by lift from the canal before it can be put on to the land. When canal water is available the tendency is great to let the water flow on just as one would turn on a tap and allow it to run. No extra labour is involved, and no extra charge is made for the quantity of water used, as the water rate is solely for the area brought to maturity. But in the case of a well, all water raised has labour expended on it, and so the cultivator is careful that it is only used as the crop requires it, and that it is made to go as far as possible. The very appearance of the fields under the two systems of cultivation is different. The beds, or *kyaries* as they are termed in the North-West Provinces, into which the plots are divided by means of small embankments which direct the flow of water to particular parts, are numerous and small in the case of cultivation by wells; in canal cultivation, on the other hand, they are few and large. Colonel Forbes, the head of the Irrigation Department, pointed out to me that for every bed which exists in the case of canal cultivation there would be from five to eight beds on the same area if a well were used.

Loss by percolation in watercourses.

Major Clibborn, in his Report, remarks on the loss sustained through percolation in watercourses, especially in the case of long canal channels, and in village watercourses. Well watercourses, on the other hand, are short and are well-made as compared with those of a canal. The canal courses in villages are the property of the cultivators, and are made by them; but, as the villagers have no interest in the economy of canal water, the courses are often badly kept, and the loss by percolation is very great. Advance in this direction might be effected if the Irrigation Department had more powers of construction and of improvement of watercourses, and if they could recover the cost by a small rate. It is very difficult for an isolated cultivator to arrange for the water to run to his field when it first passes through his neighbours' fields. The main courses, which are kept up by Government, are, as a rule, in excellent order, and the loss by evaporation and percolation is comparatively small.

Irrigation Department might have further powers over watercourses.

Waste of water in "flow" irrigation.

Although there is a rule to enforce the making of beds or compartments of a certain size, the *raiyats* who use the canal water will evade the rule if they can, and the canal officers find it difficult and harassing to enforce it stringently. In districts to which canals have recently come, the people are new to this particular mode of irrigation, and this fact affords another reason for the authorities not wishing to press too much at first for compliance. As a consequence, water, when distributed from a well, is generally put on to just a sufficient depth and no more, but canal water is often run on to an unnecessary extent. Major Clibborn concluded from his investigations that rather more than three times as much water is used for irrigating an acre from a canal as from a well. The average depths of water used were 0·9 inches from wells and 2·86 inches from canals. This has led to a consideration whether, in future, canal water should not be supplied by "lift" only, instead of by "flow"; but it is felt that the plan would not work, inasmuch as a cultivator will often wait until the last moment, in the hope that rain may come and so enable him to dispense altogether with the canal water, or rather, with having to pay the rate for it. Thus, very frequently, he will not take the canal water until positively obliged to do so. Had he then to raise all the water by "lift," he would not be able to get enough labour to irrigate the whole area in the time, and the canal would fail in accomplishing its object.

Should all canal water be raised by "lift"?

Failure of attempts to fix payment of water rate by quantity used.

Similarly, all attempts at devising a scheme for payment of water by the *quantity* used have failed.

At Multan, Ferozpore, and Shiyali, I observed instances of beds or compartments being made too large; at Hospet, on the contrary, far more care was exercised, and the compartments were not much larger than in "garden" land.

In the Punjab it is found, as the result of increasing canal irrigation, that the tendency is to grow more wheat. This is the case whenever the canal runs long enough to supply moisture for sowing the crop, inasmuch as a single fall of rain afterwards, about January, suffices for wheat.

A disadvantage in cultivation by canals as compared with that by wells is that in the latter case a man has always some work to do, and is more independent than if he relies on a canal which may only be let on to his land at intervals.

Hence when there is the chance of giving the land a good soaking the tendency is to put a great deal more water on it than is really necessary.

Again, a *raiyat* is not so careful in levelling his field when he uses canal water as when he has to raise water from a well, and thus waste is incurred with canal water.

"Over-cropping" of land, consequent on canal irrigation.

98. This leads me to the consideration of the "over-cropping" of the land, consequent on the introduction of canal irrigation. The Report of the Famine Commission records instances where deterioration of soil has followed the coming of canals into districts previously unsupplied by them. Undoubtedly, with the introduction of a canal into a district comes also the tendency to force the land to bear more crops than it ought to, unless it be plentifully supplied with manure, which is seldom the case; also, the careless use of the water causes the washing-out of those constituents of the soil which should form part of the crops. Moisture and heat are necessary to bring the soil-constituents into activity, but over-watering not only produces a state of stagnation and coldness, but goes farther, and actually removes the very plant food which it has been instrumental in bringing into an assimilable condition.

Depends upon the *kind* of water used.

It is necessary to make the reservation here, that much depends on the *kind* of water employed. If it be what may be termed a "poor" water, that is, one without any silt, or with but little mineral salts in it, the effect will be a "washing-out" one, but if silt be brought with the water, or if it contain fertilising salts, the result may be a "renewing" one. It is often the case that canal banks are cut, and that the water is let on the land for the sake of the silt, the principle of this waste of water being that the more water that is used the more silt is there deposited. Thus, the Tanjore Delta, which is all rich rice land, has been formed entirely by silt brought down from the river Coleroon, a branch of the Cauveri.

Preference of cultivator for well water.

99. Where both canal and well water are available the preference of the *raiyat* is very marked for the latter, more especially for his "garden" crops. He calls the canal water "cold," the well water "warm;" and when the well water is brackish (*khara*) it has in his eyes particular virtues for certain crops, especially tobacco, which the "sweet" (*meetha*) canal water does not possess. As to one being "warm" and the other "cold," there is a certain amount of truth in this, for irrigation is employed mainly in the cold season, when the canal water is the colder of the two; besides this, the canal water often comes over clean river beds, straight away from the melting snows, whilst the well water is below and is impregnated with the earth's salts. The chief reason, however, is, I believe, that over-watering with canal water brings about a cold and stagnant state of the soil, such as happens with an imperfectly drained clay soil in England, and causes a "chilling" which the well water, since used in lesser quantity, does not produce. In reading papers which have been written on this subject I have been amused to notice the speculations indulged in on this point, whereas in none of the investigations has a single record been given of the actual temperature of either the canal or the well water. The speculations as to the particular salts contained in either well or canal water are equally random. For example, one writer speaks of "compounds of ammonia and lime," these being, as yet, unknown to science; another is not afraid to say, "the "superiority of cultivation by wells I attribute without "hesitation to the presence of lime," and this without any analytical data whatever to support the assertion. These points I name as showing the desirability of associating in any future investigation a scientific man with knowledge of chemistry. It is only fair, however, to Sir Edward Buck to say that he did take the precaution to have an analysis of the water made when he was investigating this question of relative efficiency.

Speculations as to the differences between canal and well water.

Need of a chemist.

I was led to examine this question myself, so far as occasion permitted, and, in April 1890, I was conducted by Mr. Holderness, the Director of Agriculture in the North-West Provinces and Oudh, to a village named Rawatpur, not far from the Cawnpore Experimental Farm. Here a well was shown to me which was considered to yield water especially good for the tobacco crop, and to be much superior to the water from the canal (Cawnpore branch of the Lower Ganges Canal) which flowed near by. I took samples of the well water, and Mr. Holderness subsequently collected others from the canal supply. These I sent to my laboratory in London for analysis.[*]

My analyses of canal and well waters.

The composition of the two waters may be represented as follows, the quantities being stated in grains per gallon :—

———————	Canal Water.	Well Water.
	Grains per Gallon.	*Grains per Gallon.*
Sulphate of Lime - - - - - - -	1·80	10·71
Phosphate of Lime - - - - - - -	·13	1·59
Carbonate of Lime - - - - - - -	4·55	4·09
Carbonate of Magnesia - - - - -	3·52	13·23
Chloride of Potassium - - - - -	·63	·59
Carbonate of Potash - - - - - -	·60	—
Chloride of Sodium - - - - - -	—	14·69
Nitrate of Soda - - - - - - -	—	8·66
Carbonate of Soda - - - - - -	2·39	16·41
Oxide of Iron and Alumina - - -	·28	—
Soluble Silica - - - - - - - -	1·26	1·96
TOTAL Solid Residue per Gallon - -	15·16	71·93
Free Ammonia - - - - - - - -	·001	·002
Albuminoid Ammonia - - - - -	·007	·005

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[*] For full analyses *see* Appendix C.

The main differences.

From these figures it will be seen how very marked is the difference in the amounts of solid constituents contained in the respective waters, the canal water having only 15 grains to the gallon, as against 72 grains in the well water. Lime does not constitute a leading distinction; altogether there are 3·36 grains of lime in the canal water and 7·56 grains in the well water. The divergence in magnesia is much more marked. It is mainly, however, in the soda salts present that the waters differ, and in the nitrates, chlorides, and sulphates. The canal water contains 1·40 grains of soda, but the well water has no less than 20·53 grains per gallon.

Chloride of sodium (common salt), nitrate of soda, and carbonate of soda, with carbonate of magnesia and sulphate of lime, constitute the special properties of the well water. It is further noticeable that the well water does not contain more, but rather less, potash than the canal water, and that it is as salts of soda, and not of potash, that the greater part of the salts exist in the former. This I was hardly prepared to find, fully expecting that nitre (nitrate of potash) would be present to a large extent.

Repeated applications of the well water would, accordingly, be equivalent to a manuring with readily soluble salts such as nitrate of soda, carbonate of soda, common salt, and salts of magnesia. To this is, no doubt, due the believed fertilising quality of the well water; in other words, it is owing to the large amount of salts held in solution.

Incidentally it may be mentioned that, as regards organic purity, both waters are good, and have but little ammonia, though a water with so much salts dissolved in it as the well water has would probably not be palatable.

Need of further chemical study.

This is but one analysis of well water, but, from my observations, I am sure that the composition of the water varies very greatly in different parts. In some cases the salts, instead of being beneficial, are considered hurtful to crops. A chemical study of this subject would lead to interesting and useful information, and give definite knowledge instead of the present uncertainty that exists.

Analyses by Mr. Venis.

I have found a record of two analyses of Ganges river water, taken at Benares by Mr. G. Venis, which show the total solids contained in the waters to be 16·52 and 19·95 grains per gallon respectively. These figures do not differ widely from my own. The dates of Mr. Venis's samples were December 19th 1888 and February 6th 1889.

Removal of superfluous water.

100. Having spoken of the means of supplying water, it is well to mention also means of removing water, or rather, of preventing the harmful effects of a rapid flow of water. Some of these have been instanced already. Thus, improvement of land cut up by ravines has been spoken of in Chapter V. paragraph 70, subsoil drainage and damming up of rivers, in paragraphs 90 and 93 of the present chapter. A further plan is that of embanking arable land, in order to stop the rapid flow of water over its surface at the beginning of the rainy season. It is in the Central Provinces, perhaps, that this has been most effectually tried, for it has been found that by embanking fields the rich topsoil is not washed away, and a quantity of water is also held up, which comes in usefully for irrigation later on. Great encouragement has of recent years been given to the spread of this practice, more especially by the issue of vernacular notices to the effect that such improvements will be exempted from assessment at the next Settlement. The Administration Report of the Central Provinces for 1888–89 says, on page 8 :—

Embankment or *bunding* of land.

Much done in Central Provinces.

Encouragement given to practice of *bunding.*

> "The failure of rain in October 1888 showed the advantage of "embanking land, the 'bunded' fields retaining moisture enough for "sowing, whilst the open land was hard and dry."

In some parts of the Central Provinces it is found that by holding up the rain water a crop of wheat can be taken after the rice crop is off. Irrigation has even been proposed for wheat itself, but there is considerable fear that the crop will be attacked by "rust." In the absence of embankment or *bunding* of land, as it is termed, it is found that manure is not properly used, for, if put on, it would be washed away to a considerable extent. It is well to point out that it is not so much the total quantity of rain that falls, but the amount that falls at one time, that may do harm to the land.

It is possible that a good deal of existing swampy land might be reclaimed by draining the water off, but this could hardly be carried out unless a Government grant for drainage purposes were made.

Draining of swampy land.

101. I might now indicate, by way of instances, some districts which came under my notice, and which stand in need of further irrigation. In the Punjab, Multan and Hissar are two places where a quantity of land could be brought under cultivation if canals were more extended. The success of the Sidhnai Canal has been mentioned, but there is also a great unwatered tract enclosed between the rivers Chenab, Ravi, and Sutlej. The land here is rich; all it wants is water. At Hissar, too, the canal supply is very uncertain.

Districts in need of further irrigation.

The Punjab.

In the North-West Provinces, Mirzapore is badly off for irrigation; there is none from canals, and but little from wells. Agra, Gwalior, and Jhansi are all precarious tracts. The first named is on the edge of the "shrinkage" of the monsoon, *i. e.*, the monsoon rains may stop short before reaching them. Gwalior is likewise badly placed; the wells are 60 feet deep or more, and the district is too far off for irrigation to be satisfactorily brought to it. At Jhansi, wells are over 40 feet deep; *bunding*, as stated, is being tried here. There is also scope for extension of well digging near Cawnpore.

North-West Provinces.

In regard to Bengal, mention has been made of the good that would follow the making of irrigation reservoirs in Lohardaga (Chota Nagpur), and Mr. Basu mentions tracts in the valley

Bengal.

of the Amanat and the plain of the river Son where irrigation canals and reservoirs could easily be made.

Rájputana.

Deccan.

Madras.

Mysore.

Central Provinces.

In Rájputana, Ajmere is known as a precarious district which the monsoon frequently does not reach. Parts of the Deccan, again, stand much in need of irrigation, whilst, coming down to Madras, we find numerous other instances. Anantapur is one of the driest districts in the Presidency, being badly situated for both the south-west and the north-east monsoons; there are only about 37 wet days in the year, and, with an annual rainfall of only 23 inches the water soon dries up. Tanks are, therefore, very uncertain. Bellary, Kurnool, Coimbatore, and Madura are also very precarious districts. At Bellary the wells have to be made in the solid rock, and are 45 feet down; there are no canals, and but few tanks. Kurnool has few wells, the supply of water is poor, and the water itself often brackish. Coimbatore, being situated on high ground, has no irrigation except from wells, and they have to be taken about 45 feet down, and through rock. At Madura there is great want of water, and all the tanks have been made that can be made; both canals and wells are, accordingly, wanted here. The possibility of extending wells in the Madras Presidency is shown by the fact that, during the recent distress, in the Chingleput district alone the Government have advanced 2¾ *lakhs* (say 20,000 *l.*) to enable 19,000 more wells to be begun. Mr. Nicholson has pointed out, also, that the waters of the Pennér and Hagari rivers might usefully be stored for irrigation purposes; also that a storage scheme for Kallápuram, whereby 2,000 acres might be irrigated, is quite feasible. The centre of Mysore is another part which is very poorly off for water, and wells might, with great advantage, be constructed. The possible advantage of tanks in certain districts of the Central Provinces has been indicated, as also the benefits that would follow the embanking or *bunding* of land. The Saugor district is a case in point.

Interdependence of water and manure.

102. There is a matter which I do not wish to pass over, but the full consideration of which I postpone to the next chapter; I mean, the interdependence of water and manure. The one without the other is productive of but limited good, and, in most cases, it may be said that either of them alone is useless. An estimate given by Sir Edward Buck, in reference to land near Ajmere, expresses this point as follows:—“Irrigation “from tanks is lavish, and it is put on to lands which it has “robbed of its fertility, as the manure supply, before “deficient, is now totally insufficient to restore fertility. “Given unlimited manure, water will raise the rental of land “to Rs. 50 an acre; with no manure it will sink to 1 R. an acre.”

Agency by which improvement of agriculture by better supply of irrigation may be effected.

103. We must now consider how the extension of the different systems of irrigation, according as they are best suited to each case, may be carried out.

Where minor works have to be constructed, such as the digging of wells of a moderate depth, the making of shallow tanks, and the embanking of land, these may be entrusted to the people themselves, aided by a judicious system of "advances" of Government money for the purpose of beginning such works. To this system of advances the name "*taccavi*" is given.* In a later paragraph I will endeavour to show what improvements in the working of this system may be effected. But for all works of greater magnitude, such as the carrying of canals over the country, the taking of channels from rivers, the formation of large reservoirs or tanks, dependence can alone be placed on Government. It is true that in former times the people themselves made inundation canals, and constructed large reservoirs which are still objects of admiration, but the people are not so likely now to construct fresh ones, but rather to rely on the Government; besides this, whatever may be said of the excellence of the earlier constructions, the engineering skill of the Irrigation Department is now able to carry out more effectual and lasting work. It is to assist the people in works which they can carry out themselves, and to do what they cannot do, that the efforts of Government should be put forward. The initiative must now rest more than ever with Government, and, as I have pointed out, a careful enquiry is necessary in the case of each separate district, so as to ascertain exactly what its irrigation requirements are, and how best they may be met. It should be a main duty of Agricultural Departments to set on foot such enquiry.

Minor works may be done by the people themselves, aided by Government.

Major works must be constructed by Government

The duty of Agricultural Departments.

104. The last paragraph leaves still open for further consideration the agency by which wells of more than ordinary depth, or those which have to be made under circumstances of special difficulty, are to be constructed. To give instances :—

The making of wells in rocky land.

Instances.

In the Coimbatore district of Madras the wells are frequently in rock, and are large and costly, the depth varying from 15 feet to 40 feet, while they have to be wide also, in order to include a spring within the area. At Bellary, similarly, I noticed that wells had to be cut through rock to a considerable depth, and had also to be made very large. Mr. Nicholson, in his "Manual of Coimbatore," speaks of wells as "being the "mainstay of revenue and the *raiyat*," and he says :—"Unless "by great irrigation schemes or development of wells, it is "not probable that production can keep pace with human "reproduction." In another place he says :—"Well irrigation "alone prevents minor famines;" but he also instances frequent cases where "wells have been begun and given up "because of the interposition of impenetrable rock." In my own enquiries in these parts I found that the cultivators often shrank from taking Government advances for digging wells, because of the chance of rock intervening, and the consequent difficulty of cutting through it; they might have to go to an uncertain depth, with the chance of not finding water soon enough to make the well profitable to work, and thus they might expend the whole advance and yet not obtain water.

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* *Taccavi* system—a system by which advances of money at a low rate of interest are given by Government to cultivators for agricultural improvements, and mainly for the digging of wells. The rate of interest charged is 1 pie per rupee per month, or 6¼ per cent. per annum.

The ignorance of the *raiyat* in the matter of "blasting" of rock is a further hindrance.

Construction of wells by Government.

It is worthy of remark that in the last great Madras famine it was the deep wells that held out, so that a decided advantage follows their construction in precarious districts, an advantage which must be looked on in the light of a "protective" measure, and not as distinctly remunerative. It appears to me, therefore, that in cases of difficulty, where, on account of deficient rainfall and absence of canals, the agriculture absolutely depends upon wells, it is fully worth considering whether Government might not undertake the construction of wells. In other cases, however, it is probably better that the cultivator should be encouraged to construct wells himself; he chooses his own spot (and no engineer could do it better), and he employs his own labour and materials. Wells could undoubtedly be constructed more cheaply with the landlord's materials than with those which the Government would have to obtain and bring to the spot.

It is only in exceptional cases, therefore, that I consider the construction of wells by the State is desirable. But it would be easy, in many cases, to make the system of Government advances more known and more popular, and to induce the cultivators to avail themselves further of its advantages.

Major Clibborn, in the Report already referred to in paragraph 97, concluded that, as regards the North-West Provinces, a rate of *Rs.* 2 per acre of annual irrigation would cover the outlay of construction of wells. The cost would, of course, vary in different parts according to the depth and nature of the soil passed through. But it must be remembered that Major Clibborn was dealing with alluvial soil and not with hard rock, such as is met with in Madras. He reported that Government could not safely undertake the construction of wells on a large scale, but that they must leave this to the landlords (*zemindars*), and to the working of the *taccavi* system. (*See* footnote on page 81).

Proposed scheme in Madras.

Since my return from India I have heard from my friend, Mr. R. H. Elliot, of a scheme which he has laid before the Government of Madras, for the digging of wells by Government in unoccupied fields, and the loaning them out to cultivators at "wet" rates of assessment. In Madras, it must be explained, the waste land belongs to the State, and it is not an uncommon practice for a *raiyat*, after cultivating a field for some time, to throw it up and to take another, the field so thrown up remaining in the hands of Government until a fresh tenant is found. In this way enormous quantities of land may be in the hands of the State at one time. Mr. Elliot now suggests that if the Government were to dig wells in these unoccupied fields, or perhaps even on waste lands, and thus gradually turn them from "dry" to "wet" lands, not only would the country be protected against famine, but the revenue might, in the end, be very greatly enhanced. Such a project is one which would carry with it great benefits, though it is obviously only where a Land System similar to that of Madras prevails that it could be adopted.

Much can be done if Government are prepared to regard works as "protective measures."

There is no doubt that a great deal can be done in improving the water supply in precarious districts, if Government are prepared to look on the measures taken as those of a "protective" and not purely a remunerative nature. This is well expressed in a note by Colonel Mead, Chief Engineer for Irrigation, Madras. He said, in 1887,—

> "Much can, no doubt, be done to improve the existing supply to tanks "if Government are prepared to accept the benefit to the *raiyat* as a sufficient return for outlay incurred, and to consider the works as entirely "protective in nature."

Management of small tanks by the people.

105. I found a very general expression of opinion, both in Madras and in Bombay, that the management of small tanks should be left in the hands of the village communities, or else be under the Collector of the district, and not be administered by the Irrigation Department. At Belgaum there are a great many tanks, and these are managed by the villages, the water being let out for a group of 100 fields at a time, the *raiyats* settling among themselves how it is to be used.

Management of canal branches by the people satisfactory.

On the other hand, the management of canal branches by the people has been tried and has not been found to be successful. Thus, the Eastern Jumna Main Canal was made by Government, but the branches by a joint-stock arrangement of the cultivators, the Government advancing money for the purpose. The cultivators, however, could adjust neither the sharing nor the payment among themselves, and Government had finally to take the management into their own hands. It has been found also in Southern India that there has been considerable neglect shown by the people in keeping irrigation channels in order. The people allow underwood to grow, and let the leaves fill up the channels and there decay; one place after the other becomes malarious and the people leave, going higher up the stream. So, too, in other parts weeds are allowed to overgrow tanks, and then the people go lower down, and leave the Government to clean out the tanks.

Repair of tanks; improvement in this respect possible.

106. Improvement can certainly be effected in providing for the more prompt and better repair of tanks. Mr. Nicholson in his "Manual of Coimbatore" mentions the case of Kondampatti village, in Udamalpet, where the repair of a large tank is quite feasible. In Bengal, Burdwan is mentioned as a part where repair of tanks is difficult, and Palamau as a division where there are many reservoirs which are out of repair. Once when at Poona, I met a number of landowners and others interested in agriculture, and an unanimous opinion was expressed by them in favour of the management of small tanks by the communities themselves and not by Government, and especially that the repairing of these should be left to the village communities.

The same opinions were expressed to me on the occasion of a similar gathering at Madras. Going on from Madras to Madura, and then to Coimbatore, more precise particulars were given me, not by landholders, but by actual cultivators. In the Madura district, where there is much tank irrigation, there were complaints of the difficulty in getting repairs done, and a desire was expressed that this work might be put under the Revenue Department rather than the Department of Public Works, the Collector being considered the person who knows the wants of the people best. The cultivators instanced the delay that takes place when a tank wants repair; how that when the *Tahsildar* hears of it he goes to the divisional officer (Assistant Collector); the latter to the Collector; the Collector to the Executive Engineer of the Public Works Department; the Executive Engineer writes to the Superintending Engineer (stationed, in this case, at Trichinopoly, there being only one such officer for three districts); he writes to the chief office at Madras, and says whether it is a matter of first or second importance, and so on. Altogether it is a long business, and in the end the year's crop is generally lost. Under the old system, I was told, the Executive Engineer was the direct subordinate of the Collector, and small works requiring no special skill could be effected at once by the Collector's direction. It was, of course, necessary for *large* engineering works to be enquired into and to wait, but three-quarters of the "major" work (anything over 200 acres of irrigation being considered "major" irrigation) was simple work of repair, putting up *bunds*, digging channels, digging tanks, &c., which any workman could do, and which needed no particular skill.

Classification of tanks desirable.

It would appear desirable, from what I gathered, that there should be a classification of tanks, and, in accordance with this, it should be determined which tanks should be managed and repaired by Government, and which by the village communities. It is clear, anyhow, that good might be done by a simplification of the process by which repairs are effected. Necessarily there must be official enquiry as to any work of magnitude, but in nine cases out of ten the repairs required are those which call for *immediate* attention, and which, if neglected, may produce very much aggravated consequences. If the circumlocution that has been instanced could be avoided, and a certain amount of discretion and executive power be given to the Collector to have these repairs effected *at the time*, the local needs would be more readily met, and expense be, in the end, spared.

The system of *taccavi* advances.

107. It remains for me to refer to the system of Government advances known under the name *taccavi*.* Though not confined to the purposes of digging and repair of wells, it is mostly for these that the advances are used, and they are the schemes which are the most satisfactory in their working. Advances are also given for embanking of land, for purchase of cattle, purchase of seed, and occasionally to assist in payment of debts. The advances are made by Government at a moderate rate of interest (6¼ per cent. per annum), and are intended to save the people from being compelled to resort to the money-lender or *baniya*, who charges a rate of 12, 18, or more per cent., and out of whose clutches the cultivators seldom get. The plan is an excellent one; but its success depends entirely upon how it is worked, and how nearly it is brought home to the people, and is adapted to their means. What is still requisite is, to make it clear to the cultivators that the system is one that will benefit them, one that will enable them to benefit themselves. If this idea could be once thoroughly grasped, the advantages, not alone to the people, but to the Government, in the form of an increased revenue from the land, would be very great.

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* *See* footnote on page 81.

The different ways in which it is administered in different parts.

Anyone going through the country as I did, could not fail to be impressed forcibly with the difference between the way in which the *taccavi* system is worked in one part and that adopted in another, and also with the dependence of the system, for its success, upon the energy and interest of a single individual, this being, as a rule, the Collector or Deputy Commissioner. Whilst the system is popular in some districts—for instance, in Belgaum (Bombay), the Native State of Kapurthala, Multan, and other parts of the Punjab—in others, such as Aligarh (North-West Provinces), it is reported that "the people will not have it on any terms;" and in Madura, Coimbatore, and other parts of Madras the complaints are great as to the difficulties put in the way of making use of the advances for the digging or repair of tanks.

When advances are made by Government agency the returns show that it is but seldom that there are arrears of any long standing, and the State loses very little on this account. The objections of the people to avail themselves of the advances do not arise alone from difficulties put in the way, or because the advantages of the system have not been sufficiently impressed upon them, but largely, also, from their own fault, their careless and improvident habits, their suspicion, and their inability to appreciate what is intended for their benefit. The most important factor in removing these hindrances is the personal interest and activity of the Collector or Deputy Commissioner.

The objections of cultivators to the *taccavi* system.

The cultivator will often prefer to resort to the money-lender, because the latter gives him the advance at once, because he asks no questions, and does not insist upon the money being devoted solely to the particular purpose for which it is given; he does not come round and see that the work is being carried out, but allows repayment at leisure; lastly, he has no intermediaries who require to be "feed." When, however, a cultivator applies for a *taccavi* advance, he complains (and frequently with reason) that the delays are long, and that the enquiries are put off; that he has often to wait several days at the *Tahsildar's* office before that official will attend to him, and that, in the end, the advance frequently comes too late to be of any use; that he is bothered by minor officials who come to see that he has not used the advance for other purposes; by others, again, who come to "pass" the work, but who one and all require their "palms' to be "greased;" and that the money, thus filtering through several hands, never comes to him to the full extent of the advance; lastly, that the Government insist on punctual payment of interest and repayment of loan. Thus the *raiyat* comes to undervalue the advantages of the *taccavi* system, and resorts to the easier method of going to the *baniya,* though it may be dearly bought in the end. Then, having once obtained the money, he will often use it for marriages and for other extravagancies rather than for the presumed object, and thus he gets involved deeper and deeper in debt.

Scope for extended adoption of the *taccavi* system.

108. I will now give some instances of the need that exists for the cultivators to be made more acquainted with the advantages of the *taccavi* system, and also of the need for better administration of the system.

North-West Provinces.

At Rura, near Cawnpore (North-West Provinces), I saw a cultivator who was constructing a masonry well at a cost of Rs. 150. This was intended to irrigate 25 acres. The cost was being paid partly out of the man's savings, partly by gifts from his family, and the remainder was borrowed from the money-lender. The man *knew nothing about Government advances.* Other cultivators here said the same thing.

Punjab.

In the Punjab Administration Report for 1888–89 it is noted, in regard to the Gurgaon district: "*Tahsildars* need constant reminding of the "desirability of encouraging advances. A lot has been done in Rewari, "but there is no reason why the number of wells should not be doubled "in the district; also well repairing should be done by *taccavi.* The "payments, when advances are made, are very punctual."

Bombay.

At Ahmedabad (Bombay) I found that the *taccavi* advances were not made use of. The *Mamlatdar* did not like the trouble attaching to them; his objection was, that he had to keep separate accounts for them.

Central Provinces.

In the Central Provinces, at Saugor, only two wells have been dug by means of Government advances in the last three years. Of Dongasara it is reported, "There might be more wells here, and the *malguzars* (land- "lords) could easily make them." The Chief Commissioner (Mr. Mackenzie), in his proceedings for the year 1888–89, points out that it is not the *debt* to the *baniya* that ruins the *raiyat,* but the high rate of interest, and the way he is cheated in settling his accounts with the *baniya.* Also he instances a case where in one division there was an extremely high mortality of cattle, and where the people would surely have been glad had help been given them; and yet there was not a single loan for purchase of plough cattle, and this entirely because the Deputy Commissioner did not trouble about it.

Speaking of Bilaspur, Mr. Mackenzie says, "The fact is, that the granting "of loans is opposed by the whole weight of the treasury and *tahsil* "establishments, and it is not till a Deputy Commissioner has made it "plain that no obstruction will be permitted, that people are able to "obtain loans with reasonable facility."

When at Madras, I met in conference a number of landholders; they one and all spoke of the difficulties in the working of the *taccavi* system; and at a similar conference at Poona it was remarked that local officers did not trouble about *taccavi* because it entailed extra work on the *Mamlatdars, Tahsildars,* and others, and they had to keep separate accounts for it.

Madras.

During my tour in the Madras Presidency I came across many instances of the non-use of *taccavi* advantages. At Salem I found that only four or five wells had been sunk in the last two years by Government aid. The people preferred to borrow locally at 12, 15, or even 18 per cent., and not to be restricted in their application of the money. At Avenashi (Coimbatore) *raiyats* borrowed locally at 12 per cent. in preference to using the Government loan. I was told that in Tinnevelly the risk of taking the *taccavi* advances was, that if a man took a loan and tried to dig a well, he had to pay whether he was successful or not, and the rocky nature of the ground made the attempt very uncertain. In cases where a man has tried and failed, I think, possibly, the rules might with advantage be relaxed.

Bengal.

In many parts of Bengal the landlords (*zemindars*) have no direct interest in the produce of the land so long as they get their rents, and they are often too encumbered to lay out capital in water supply ; the *raiyats* are too poor to do anything unaided, and, in consequence, reservoirs that used to benefit low-lying rice fields have fallen out of repair, and no fresh ones have been constructed.

Instances of energetic administration of the *taccavi* system.

109. By way of contrast, I may now mention cases where manifest advantage has followed the energetic administration of the *taccavi* system, and the popularising of its objects and advantages.

Punjab.

In the Punjab Administration Report for 1888–89 it is said : "The "increased resort to *taccavi* is in many cases due to the personal influence "of Deputy Commissioners." Again, "In the Montgomery District the "system of advances is undoubtedly popular."

In the Multan district I found that the Deputy Commissioner had, in the last year alone, given Rs. 28,000 in *taccavi* advances for the digging of wells to supplement the supply of water from the Sidhnai Canal.

Bombay.

In Belgaum (Bombay), and entirely through the personal energy of the Collector and District Deputy Collector, advances to the extent of between thirty and forty thousand rupees annually have been made during the last four years, and the number of applications have averaged 748 per annum. Advances are made for well and tank digging and repair, for embanking, for removing rank grass and weeds, for levelling ground and making rice fields out of dry land, for purchase of seed and cattle, and for cutting away prickly pear. The District Deputy Collector (Honourable Gurshidapa Virbasapa), who was in charge of two divisions (*talukas*) seven years ago, took a personal interest in the matter, and by himself explaining to the people the advantages of the *taccavi* system induced them to take it up. The Collector, Mr. Muir, issued circulars in the vernacular, and now all the seven *talukas* of the Belgaum district have adopted the system. During the seven years there has not been one bad debt, and so much work has been thrown on the *Mamlatdars* that three extra clerks have had to be obtained for this work, the cost being paid out of the *taccavi* grant. The District Deputy Collector explained to me that everything depends on the prompt examination of applications, and on not keeping the applicants waiting about at the *Mamlatdar's* office, or sending them to and fro repeatedly. The only reason that advances were not even more used was, that the people had already mortgaged their lands so much for other debts that they had no security to give for the Government advance. He was of opinion that it was absolutely necessary for the people to be ready with their payments on the day fixed, and that it would not do to allow them any laxity. With this opinion I am inclined to agree ; and, though at first I thought that where security was good some liberty might be shown, I now believe that strict enforcement of payment when due is advisable.

Central Provinces.

At Wardha, in the Central Provinces, through the personal energy of Colonel Scott, *taccavi* advances have been largely made, and in the Central Provinces generally, encouragement is given to the taking up of the advances by distributing vernacular notices (*sanads*) announcing exemption of improvements from assessment at the next Settlement. Mr. Fuller, in his Annual Report for 1888–89, as Commissioner of Agriculture, speaks of the necessity for the distribution of these notices, and deprecates delay in dealing with applications, pointing out that people should be let know that they can get advances without expense or trouble being entailed on them.

Mr. Fuller reports, further, that very great progress has been lately made in the amount of the loans advanced under the Agriculturists' Loans Act (No. XII. of 1884). The figures for the last three years are as follows :—

YEAR.	Number of Loans.	Amount.
		Rs.
1887–88 - - -	1,444	26,000
1888–89 - - -	1,692	45,285
1889–90 - - -	2,535	1,07,459

Such a marked increase is highly satisfactory, and shows what can be done by the exercise of personal energy. It is added that, "in the whole of the Central Provinces recoveries were made without difficulty; in only one case "was resort to coercive measures found necessary; Government realised 6·4 per cent. on its outlay under the "Agriculturists' Loans Act." Of Bilaspur, which has been mentioned in paragraph 108 as having been backward in utilising the advances, it is now said, "for several years it was "reported that the people were reluctant to take advances, "but in 1889–90 Rs. 16,768 were advanced here alone."

The *taccavi* system in Native States.

110. Native States have not been slow to realise the advantages of advances for agricultural improvements.

Jeypore.

In Jeypore the cultivators are *not allowed* to borrow money for sinking wells ; the State advances money at interest varying from 6 to 12 per cent., and the Land Revenue has increased very considerably wherever wells have been dug.

Kapurthala.

In the Kapurthala State, under British administration, the system of giving advances for agricultural improvements has been made easy, and is largely used. Within the past two years Rs. 65,482 have been distributed, mostly for digging and repair of wells. No interest is charged, and payment is recovered by seven annual instalments, beginning three years subsequent to the completion of the work. No increased revenue is taken until the improved lands have been benefited for five years. Applicants are not obliged to attend at the Kapurthala treasury, but can obtain advances from the *tahsil* treasury without delay. The time occupied in deciding *taccavi* cases rarely exceeds one month. Help is occasionally given to indebted owners in the form of advances to free them from the professional money-lender. Advances are given for new wells, for repairs, for purchase of plough cattle and seed, and for redemption of mortgage. In 1889 there were 246 new wells under construction and 73 under repair, and nearly one-half the increase of wells during the last 10 years had been made by means of *taccavi* advances. Major Massy reports that repayments are generally made with punctuality, and that there is still room for extension of well sinking. Advances for wells went up from Rs. 7,270 in *Sambat* 1942 (year 1885–86), and Rs. 6,690 in *Sambat* 1943, to Rs. 24,702 and Rs. 35,755 in *Sambats* 1944 and 1945 (year 1888–89), thus showing what can be done by personal influence and energy. I mention this case specially, because Kapurthala borders on the districts of Jullundur and Hoshiarpur, and here cultivation depends mainly on the existence of wells. On passing through this part of the country I saw wells in process of construction, but there is room for many more, and for the exercise of individual zeal on the part of Government officers in effecting the improvements that would follow.

Necessity for removal of difficulties and complaints of cultivators.

111. The foregoing instances show clearly how much has been done, and also how much can still be done, if only the matter be made a *personal* one. Were further demonstration needed, it would be found in the case I have mentioned in paragraph 101, viz., that during the quite recent distress in Madras the Government advanced money to the extent of 20,000 *l.* in the Chingleput district alone to enable 19,000 new wells to be begun. Besides this, nearly 10 *lakhs* (say 72,000 *l.*) were advanced in the Kurnool, Bellary, Anantapur, and Cuddapah districts for well digging, and 1¼ *lakhs* (say 9,000 *l.*) under the Agriculturists' Loans Act.

The want of capital on the part of the *raiyat* is undoubtedly a main source of the difficulty in enabling him to undertake the construction of wells, tanks, &c., on his own account, and, therefore, the aid of Government may most advantageously be called in to assist him and to better the agriculture of the country. But it is incumbent that every reasonable difficulty that stands in the *raiyat's* way, and which prevents him from availing himself of the advantages, should be removed.

I do not say that the objections and complaints of the cultivators are valid ones in general, or that the indifference of the people is not mainly their own fault, but there are ways in which procedure may be simplified, and the system of advances be made more popular. And here, while suggesting some improvements, I would desire not to be misunderstood, nor to hint in any way that Government are not fully alive to the importance of urging on their district officers the carrying out of the system; nor, again, am I forgetful of the great good that has been done in the past. But the subject is one which cannot be forced too often or too strongly upon the notice of Government and its officials.

Ways in which the *taccavi* system may be rendered more popular.

112. In the first place, the issue of vernacular notices, setting forth the advantages of *taccavi* advances, should be more widely adopted, and these should be supplemented by the personal activity of the district officer. In certain cases, as has already been done in some parts, there might be added special inducements to the taking up of the advances, such as the securing of exemption of improvements from assessment at the time of the next Settlement. I am quite aware that the Government have declared in India generally that they will not tax improvements effected by private capital, including those made by means of *taccavi* advances; but, as a matter of fact, this promise is rendered nugatory in many parts, inasmuch as taxation is raised, not on account of the improvements directly, but on the general grounds of rise of prices, construction of new roads, extension of railways, and other means of communication; consequently, there is no certain security under the present system that private improvements will not be taxed. As long as this continues it will certainly act as a bar to agricultural improvement, and will prevent the outlay of private capital on wells and minor works of irrigation. I think, therefore, that the system

The non-taxation of improvements.

should be relaxed, at least to the extent of securing to the man who digs a masonry well that he shall not be directly or indirectly liable to any rise of taxation on account of the improvement which he has effected by the expenditure of his private capital upon it.

There is little doubt that had such a provision existed in reality as well as in name, a great many more irrigation works would have been carried out by private effort. A single instance will make this clear. In a Resolution of the Revenue Department of the North-West Provinces and Oudh, No. 898A. of 1889, a comparison is drawn between the four districts Ghazipur, Jaunpur, Ballia, and Benares, which are under permanent settlement as regards the Land Tax, and the adjacent and similarly situated districts which are temporarily settled, and, consequently, are liable to periodical revision of the Land Tax. In the former, 55 per cent. of the cultivated area has been brought under irrigation by wells, tanks, and streams, and in Jaunpur alone 55,224 wells have been dug by private capital. But in the temporarily settled districts only between 16 and 17 per cent. of the cultivated area has been brought under irrigation from wells and other sources, exclusive of canals. If the land under canals be added, there is, even then, only a total of 22 per cent. of the whole cultivated area of the temporarily settled districts under irrigation, as against 55 per cent. in the permanently settled districts, there being no canals at all in the latter. Private efforts, therefore, under these circumstances, have done far more than all the aid of Government, even including the making of canals. The points here brought out are well worthy of consideration, and it has further to be remembered that anything which induces the people to invest money on the land gives them a permanent interest in the continuance of the English rule.

Avoidance of delay in giving advances and in making repairs.

Next, all hindrances to and delay in giving advances must be removed. The *Tahsildars* and others must know that it is not a matter of their choice whether or when they will attend to applications, but that it is their clear duty to expedite the advances. A fair interval must be allowed for an improvement to tell, before payment of instalments is called for. This done, I am in favour of strict adherence to the rules as to payment on the date when due, and I think that the rate of interest is well within the cultivator's means.

Again, repairs should be more promptly attended to; and minor repairs, as also the management of the smaller tanks, should be left to the village community themselves, or to the Collector's authority.

In certain cases, such as that instanced, where a man, after taking a *taccavi* advance for digging a well in rocky ground, has failed to reach water, the rule might be relaxed in his favour, if it be clear that he has spent the advance in the endeavour.

Transference of surplus from one district to another.

113. An improvement might be effected in the method of disposing of surplus funds accruing from grants made for *taccavi* purposes.

When the *taccavi* grant for any district has not been fully applied for, so that a surplus is over, this surplus might well be transferred to another district where the applications may have exceeded the original grant made for the purpose.

Allocation of money to district officers, which must be spent for advances.

It is also worth the consideration of local Governments whether a certain sum of money should not be given annually to each Collector or Assistant Collector, which he would be *bound to expend* in advances for wells or similar improvements. This would not leave it so much a matter of choice as it is at present with the district officer whether he will exert himself or not in the giving of advances for agricultural improvement.

A share in the administration of *taccavi* advances should be in the hands of the Agricultural Department.

In the last place, I am strongly of opinion that some share in the administration of *taccavi* advances should be put in the hands of the Provincial Agricultural Departments. It would clearly be unwise to take any step which would bring about collision between the existing Revenue Authorities and the Agricultural Departments, and, therefore, the control and disbursement of *taccavi* advances could hardly be entrusted to the Provincial Directors of Agriculture. But, at the same time, the Director of Agriculture is the person who should best know the agricultural needs of his Province, and he should be enjoined to give his special attention to the extended working of the *taccavi* system. Further, he should be empowered to advise the Revenue Authorities generally, and to report on specific cases, either of special need, or of non-observance in the application of the funds which have been granted.

The duty of the Director of Agriculture.

It is a misfortune attending the position of the Director of Agriculture that he has no immediate executive power, but he should certainly, I think, be entrusted with the share in the administration of the *taccavi* advances which I have indicated.

CONCLUSIONS.

CONCLUSIONS.

114. Inasmuch as differences in agricultural systems are found to be largely due to differences in the facilities for water supply which are possessed by various districts, Improvement in Agriculture will be effected by any means which modify these existing differences. Of this nature are the extension of irrigation to dry and precarious tracts, the carrying of canals to districts which have no other system of irrigation available, and the digging of wells where canals cannot be brought. The agency by which such work can be carried out is twofold. The people can construct minor works, such as the digging of shallow tanks, the embankment of land, and the making of wells of moderate depth. But the carrying out of major works, such as the construction of canals and the formation of large reservoirs, can be achieved only by Government. The efforts of the people should be assisted by encouragement given to them by the State, and, in particular, by the fuller and freer application of the system of *taccavi* advances.

The Government and the Irrigation Department have done a great work in the past in pushing on irrigation schemes which have been of enormous benefit to the country; all that is wanted is to continue the work. I have shown that there is still great scope for extended action in this direction. More particularly can an immense deal be done by making known and by popularising the *taccavi* system, and by providing for the more prompt repair of tanks.

The special work of Agricultural Departments in this connection is to make an "agricultural analysis," such as that referred to in the Government of India's Resolution of December 1881, whereby the requirements of each district in the matter of irrigation may be ascertained, as also the best means by which the improvement may be effected. In such an enquiry the assistance of an expert engineer is required, and that of a chemist may also at times be useful.

RECOMMENDATIONS.

115. I recommend :—

The extension of Canals and other means of Irrigation to districts which are in need of them.

The encouragement of minor works of Irrigation by rendering the system of *taccavi* advances more popular.

The giving to Agricultural Departments of a share in the administration of *taccavi* advances.

The prosecution of Agricultural Enquiry in order to ascertain the requirements of each district in respect of irrigation.

CHAPTER VII.

MANURE.

CHAPTER VII.

MANURE.

116. THIS subject, like the foregoing, is one of the very highest importance in a consideration of Indian agriculture and its possible improvement. Water and manure together represent, in brief, the *raiyat's* chief wants. In some respects the latter is the more important requirement, for, whilst attention has already been turned to the supplying of water for agricultural purposes, but little has been done towards giving the *raiyat* more manure. The reason is, I believe, that whereas no one has doubted the value of water, and it can, moreover, in many cases be brought from outside and redundant sources, the means of supplying manure, on the contrary, do not appear ready at hand, and there has been, and still is, uncertainty as to the use and value of ordinary manures such as cattle-dung, bones, oil-seed refuse, nitre, &c.

Absence of application of scientific knowledge to practical agriculture in India.

This is principally due to a want of scientific knowledge, and of its application to practical agriculture. We are still to-day discussing whether cattle-manure loses any of its value by burning it as fuel; whether it makes any difference how manure is preserved and stored; whether urine has any value; whether bones ought to be used in the country, or might be allowed to go for export. While this is the case, it is hardly to be wondered at that Government are not anxious to take up the question of manure supply in the same way as they have that of water. This want of definite knowledge, and the absence of any-one acquainted with Indian agriculture, who is at the same time able to speak authoritatively on points of agricultural chemistry, constitute a great failing in India, which calls for early remedy.

Importance of manure.

117. In Chapter V., when dealing with the question of the possible exhaustion of the soil (paragraph 50), I quoted several instances in which reference is made to the importance of manure, and to the insufficiency of its supply for keeping up the soil's fertility. Also, in Chapter VI. (paragraph 102), the difference between manured and unmanured land was shown in the case of Ajmere. The following further examples may be given:—

Mr. Nicholson writes in reference to Coimbatore:—

> "That progress is possible cannot be doubted. In seasons of serious
> "drought, such as in the north-east monsoon of 1881, there were a few
> "acres of decent crop on land absolutely similar and contiguous to that
> "producing almost *nil* crops, and in one case the *cholam* was almost equal
> "to that of garden land. This was simply due to *manure* and the careful
> "cultivation of small areas."

Again, speaking of Erode, Mr. Nicholson says:—

> "No greater contrast, save between garden and ordinary dry crops, can
> "be seen than between the ordinary upland crops, especially in a year of
> "poor rainfall, and the very same species of crop on a piece of newly-

"reclaimed or well-manured land. In 1291, a year of drought, there was "an opportunity of making the contrast, the well-manured dry land in the "most prominent case belonging to a *Pariah*, and having an excellent "*cholam* crop, while surrounding fields had practically *nil*. The *raiyats* are "perfectly aware of the reason, and allege want of capital and pasture."

Proverbs current among the people.

There are numerous proverbs current among the people as to the necessity and value of manure, but the practice is often not as good as the precept.

Mr. Benson gives, along with others, these from Kurnool:—

"*Turva* (a kind of soil) hungers after manure as a Brahman after *ghi*;" "a field without manure is as useless as a cow without her calf" (meaning that she will not give milk unless the calf is before her).

Mr. Nicholson quotes these:—

"Old muck and lots of water;" "turn dry land into wet, pen your "cattle (in the field), and feed straw to them;" "muck is better even than "the plough." "If manure is useless (good) soil is useless;" or "manure "is better than good soil."

Interdependence of water and manure.

118. It has already been mentioned in the last chapter (paragraph 102) that water and manure are really interdependent, and that the supply of the one must be considered in reference to that of the other. In parts where rainfall is sufficient, manure alone may have to be sought, and where there is freshly-reclaimed or virgin soil, or land enriched by silt, the supply of water alone may suffice. But these conditions seldom prevail. In the course of my enquiries I found that in every part where rainfall was light, water and manure were mentioned together, and it may be said, without fear of contradiction, that one is necessary to the other, and that without the presence of both, the full benefit of neither will be obtained; in brief, they are interdependent. This is well set forth in the following extract from the Report of the Director of Land Records and Agriculture, Bombay Presidency, 1888–89:—

"It cannot be doubted that (1) character and distribution of rainfall, (2) "want of capital, and (3) want of manure, are the most important factors "which regulate the demand for canal irrigation. . . . . . . As "regards manure, the difficulty is great. Irrigated crops trench on the "temporary fertility of the soil, which must be restored either by manure "or rest. Irrigation, therefore, cannot be carried beyond the limits which "the supply of available manure fixes."

A practical proof of the truth of the above is seen in the sugar-cane cultivation around Poona, the entire industry being the outcome of the joint supply of water and of manure, whereas neither, by itself, would have been sufficient. It was not until the canal was brought here that the sugar-cane cultivation sprang up, and then the growers found that they must have manure as well. Meerut, Amritsar, Hoshiarpur, Máhim, Avenashi (Coimbatore), and numerous other towns, furnish instances of the same truth. Almost every village site in the North-West Provinces is in itself a similar example. In the centre are the habitations, clustered together, probably for purposes of defence in past times. Here are the wells, used alike for drinking, washing, and irrigation purposes. Here, too, the manure from cattle, the sweepings of the houses, &c., are nearest at hand, and are available for the fields closest by, these being also the ones frequented by the people for purposes of nature. As a consequence, it is here that both water and manure are most used, and that the richest and best cultivation is carried on, sugar-cane, poppy, castor-oil bean, potatoes, and vegetables of all kinds being grown. This is the inner circle, or "garden" culture. Next comes a circle lying beyond this, but neither so much manure nor yet so much water can be spared for it, and the crops, though still good, are not so good, nor, as a rule, of such a remunerative character; pulses, wheat, barley, and oil-seeds are more general. Next is a third or outer circle, which is only partly manured, and only occasionally watered, and where cultivation is still less high. Lastly, there may be a fourth or outlying part, never bearing more than one crop a year, a summer crop one year, and a winter crop the next. This land gets no manure and no water except the rainfall, and may be termed "dry" land. Thus, one is able to draw, as it were, successive rings or belts round a village, each belt, as it is further removed from the centre, indicating less intensive culture, and also the close interdependence of water and manure. The rent may accordingly vary, as I found it do in a village near Bilhaur, from Rs. 30 in the central zone, to Rs. 15 in the second, Rs. 10 in the third, and Rs. 7 in the outlying portion. This was repeatedly pointed out to me by Sir Edward Buck during our tour in the Cawnpore district.

It may be said, generally, that manure goes first to the "garden" land (watered by well), then to the "wet" land (watered by "flow"), and what is over goes to the "dry" land (watered by rain only).

It is not that the soil was originally different in quality, though this may sometimes have been the case, thereby inducing the people to pitch their habitations where it was best; but it is mainly the manure, the water, and the resulting cultivation, that have brought about the change. It would be of little use to extend the supply of water unless there were the manure to back it up. The converse is equally true; at Hissar (Punjab) there is plenty of manure, but it is not made use of because there is not water enough. Bengal, on the other hand, furnishes many instances of an abundant rainfall but deficiency of manure. As a contrast to both these, Meerut and Hoshiarpur are examples of what can be done by a sufficiency of each, night-soil being largely used there in conjunction with well water. Similarly, Amritsar and Poona prove what can be done with canal water and manure. It is a common saying that, if you give a *raiyat* water and manure he will grow a crop even upon stones!

Indian cultivator not ignorant of value of manure.

119. The Indian cultivator shows by the money which he is willing to pay for manure when able to afford it, that he is by no means ignorant of its value. When he burns the cow-dung which he collects, he does it, as a rule, rather from necessity than from want of knowledge of its worth. That, when he has manure, he often does not preserve it well, or use it to best advantage, is, however, the result of ignorance.

Sums spent in manuring the land.

At Máhim (Bombay) I found that Rs. 96 an acre was quite an ordinary amount to spend in manure for the "garden" crops. Even larger sums than this are expended over *betel* vines, as much as Rs. 280 to Rs. 380 an acre being given out in manure, while for ginger, sugar-cane, and plantains the cost frequently goes up to Rs. 160 an acre. A cultivator thus graphically described to me the effect of manure on the ginger crop he was cultivating; he said:—"I use manure, and 3 or 4 sons "come to each plant." At Poona, as much as Rs. 200 per acre is spent on manure for sugar-cane; at Amritsar, Rs. 43 an acre for the potato crop; at Hoshiarpur, Rs. 60 an acre for sugar-cane.

Nor is it in the quantity of manure alone that the Native often displays great foresight. He also often knows *when* to put it on, and for *which* crop to use it. He knows that he must not use it on "dry" land but on "wet" land, where it will decompose. He knows, too, the harm of using *fresh* dung, and that it will attract the white ants, and that they, in turn, will destroy the crop.

Plan of present chapter.

120. I propose now to review the different ways available in India for manuring the land, and then to see to what extent each manure is made use of, to consider what relation its supply bears to the wants of crops, and how the supply may be improved and extended.

Cattle-manure.

121. The most general manure, alike in India and in England, is cattle-manure, or, as made in England, farmyard manure. But, whilst in the latter country it has to be, and can be, supplemented, and even in part replaced, by artificial manures, this is not the case in India, and cattle-manure is the universal fertiliser and often the only one available. When, therefore, we find it the general practice, even in villages, to burn a large proportion of the dung from cattle as fuel, and when, on nearing any town, we may see troops of women carrying in baskets on their heads, the cow-dung cakes or *bratties*, which they have made into cakes and dried in the sun, we cannot but pause to ask ourselves whether the burning of these cakes as fuel does not imply a great agricultural loss. Some have maintained that it does not, for they say that the ashes are saved and used on the fields, and assert that is practically the only thing of value in the dung,; others hold that, even if the nitrogen be lost in the burning, the cattle are so poor, and so poorly fed, that there is but little nitrogen to lose, for the dung is of very low quality, whilst even what is lost is recovered in the extra amount of nitrogen which exists

Statements made as to the poor quality of Indian cattle-manure, and the non-loss in burning it.

in the rainfall in India. Such statements as these have been made, even quite recently, by men who, though not agricultural chemists themselves, have not hesitated to express boldly their opinions on points which they were not able to investigate for themselves, nor were qualified to pass judgment upon. And so it has come about that, from an error as to the amount of nitrogen in the rainfall, many theories have been built up, and but little real investigation has been done. I do not mean to say that I have been able to investigate the question at all thoroughly, but I have done so sufficiently, at least, to satisfy myself of the incorrectness of many of the theories propounded, and to show that cattle-manure in India is not the poor miserable stuff it has been represented to be, but that it must, and does, lose a very great deal if it is burnt for fuel, this loss *not* being recovered in the rainfall. Even *were* the latter to be the case, we should have a further difficulty; the districts of slight rainfall, where most dung is burnt (because wood is most scarce there), would get least nitrogen back, for the greater part would be transferred to the more rainy and more wooded tracts.

My own investigations.

To satisfy myself on these points, I obtained, through the kindness of Mr. R. H. Elliot, of Bartchinhulla, Mysore (whom I was visiting at the time), a number of samples, not only of the solid droppings of cattle, but of the urine and the drainings from manure heaps; also samples of the ashes of the same dung after burning cakes made from it; samples of leaves used for litter, of castor-oil refuse (*castor poonac*), earth-nut cake, &c. I must not burden this part of my Report with all the analyses, but, referring to the Appendix for these,* I will now only give sufficient data to enable a comparison to be instituted between English and Indian cattle-manure, and to establish such other points as I may wish to demonstrate. The samples taken were sent to London, and analysed in my laboratory there. The cattle-dung was composed of the solid droppings of lean working bullocks, taken when fresh and put in a tin box, thus reaching me simply in the air-dried condition. Analysis A is my own; analysis B is one by Mr. John Hughes, of London, of the sun-dried cakes; C is a standard analysis of English farmyard manure; D is an analysis by myself of the ashes left after burning cakes made from dung similar in composition to that given in column A; E is an analysis calculated from the results quoted in columns A and D.

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* For full analyses *see* Appendices D, E, F, G, H, J, K

TABLE VIII.

Analyses of cattle-manure.

ANALYSES of CATTLE-MANURE (Indian) and FARMYARD MANURE (English).

	A.	B.	C.
	Dung of Lean Cattle (Indian). [Air-dried.]	Sun-dried Cakes of Cattle-manure (Indian).	Farmyard Manure (English).
Moisture - - - - - - - - - -	19·59	7·22	66·17
* Organic matter - - - - - - - -	59·26	65·32	28·24
† Mineral matter (ash) - - - - - -	21·15	27·46	5·59
	100·00	*100·00*	*100·00*
* containing nitrogen - - - - - - - -	1·34	1·48	·65
equal to ammonia - - - - - - - -	1·62	1·80	·79
† containing –			
Sand - - - - - - - - - - -	14·43	18·62	1·76
Oxide of iron and alumina - - - -	3·36	—	·42
Lime - - - - - - - - - - -	1·04	1·96	1·35
Magnesia - - - - - - - - - -	·44	—	·15
Potash - - - - - - - - - -	1·16	·63	·67
Soda - - - - - - - - - - -	·34	trace	·08
Phosphoric acid - - - - - - - -	·47	·54	·31
equal to tribasic phosphate of lime - -	1·03	1·18	·68

TABLE IX.

Analysis of ashes of cattle-manure.

ANALYSIS of ASHES of CATTLE-MANURE (Indian).

	D.	E.
	Ashes of Cattle-manure (Indian) after burning.	100 parts of the Cattle-manure (Column A) would, approximately, contain, after burning, 20 parts of Ash, thus :—
Moisture - - - - - - - - - -	2·04	·89
* Organic matter - - - - - - - -	2·40	
Oxide of iron and alumina - - - - - -	9·26	1·85
† Phosphoric acid - - - - - - - -	1·37	·28
Lime - - - - - - - - - - -	1·76	·35
‡ Alkalies and magnesia - - - - - - -	2·97	·59
Siliceous matter - - - - - - - - -	80·20	16·04
	100·00	20·00
* containing nitrogen - - - - - - - -	·17	·034
equal to ammonia - - - - - - - -	·20	·040
† equal to tribasic phosphate of lime - - - -	2·99	.99
‡ containing potash - - - - - - - - -	2·05	·68

REFERENCES.

Analysis B.—Journal of the Society of Arts, Vol. XXXVIII., No. 1,948, March 21st 1890, page 441.

Analysis C. — Johnston and Cameron's Elements of Agricultural Chemistry and Geology, pages 316, 317, and 318.

I have placed the analysis B, made by Mr. Hughes, side by side with my own (A), and it will be noticed that while the sun-dried cakes have, of course, less moisture than the fresh dung, yet, taking this into account, the general composition of the two materials is very similar, thus showing that my analysis A is not that of an *exceptional* sample, but of a fair average one. This makes my deductions from column E all the stronger.

Indian cattle-manure is not poor.

Comparing analyses A and C, the Indian dung has, it will be seen, far less moisture, but, as a consequence, the organic matter in 100 parts is very much higher. The large amount of sandy matter in Indian dung is noticeable, but in other mineral constituents, notably phosphoric acid, it is quite as good as English manure, while it has double the amount of nitrogen. This is, of course, taking the two manures just as they are used, and comparing them weight for weight; but, to meet objection, even if we suppose the Indian dung to contain, not 19·59 per cent. of water only, but 66·17 per cent. like the English farmyard manure, the amount of nitrogen in it would be ·563 per cent. This is only a little below the ·65 per cent. of the English sample, and that, by the way, one of well-made dung. Therefore, whether we consider them on the same basis of moisture, or whether we take them as we really have to do with them, viz., weight for weight, the small value and inferior quality of Indian cattle-manure is by no means established. In this connection it must be remembered that the Indian dung is made without litter, and is merely the solid droppings of the cattle, with more or less earth, whereas English farmyard manure consists of a quantity of litter, as well as of the solid and liquid excrements of the cattle.

Great loss results from burning it.

Now let us consider what takes place when the dung is burnt. Analysis D shows the composition of the ashes in 100 parts, but, in order to institute a comparison, I have added column E. This is calculated from analysis D, on the assumption (founded on analysis A), that 100 parts of the original dung will leave, after burning, 20 parts (one-fifth) of ash. In analysis A the actual amount of ash was 21·15 per cent.; in another analysis which I made, it was 20·25 per cent.; 20 per cent., or one-fifth, is taken for the sake of convenience. It will be seen that 100 parts of the original dung (analysis A), containing over 59 parts of organic matter and 1·34 parts of nitrogen, lose, on burning, practically *all* the organic matter and nitrogen. The nitrogen is reduced from 1·34 to ·034 per cent., in other words, for every ton of cattle-manure that is burnt, 29½ lbs. out of a total of 30 lbs. of nitrogen (97·5 per cent.), are altogether lost.

97·5 per cent. of the nitrogen is lost.

In Chapter V. (paragraph 59) the idea was fully combated that this loss was made good by its return in the extra amount of nitrogen supposed to be contained in the rainfall.

Mr. Hughes, in the paper from which the analysis B is taken, remarks that, while the nitrogenous organic matters are lost in the process of burning, "the mineral matters, "which include the lime, potash, and phosphoric acid, remain

" in the ashes, and if these were returned to the land *the only* " *loss* (the italics are my own) would be the 33 lbs. of nitrogen "(the quantity in one ton of manure), equal to 155 lbs. of " sulphate of ammonia for every ton of cattle-manure so " employed." But I would point out that, even were this the *only loss*, it would imply a very considerable one indeed. The 155 lbs of sulphate of ammonia, putting the cost of the latter at 12 *l.* per ton, would mean, even in England, no less an outlay than 16 *s.* 7 *d.* to replace the nitrogen thus lost by burning a ton of cattle-manure. Hence the loss is not a slight one at all, but a very heavy one, and, if it costs so much to replace it in England, it cannot be a matter of indifference that so much nitrogen is lost to the soil of India by a wasteful practice. But this is not all, for there is another point that must not be overlooked, viz., that the entire value of the *organic* (or vegetable) matter is lost in the burning, and this is a matter of no small moment when, as I have shown, soils in India are generally notoriously poor in vegetable matter. Nor even this alone, for dung has an important *physical* as well as chemical effect on the soil, and it acts as a retainer of moisture. Indirectly it may be said, therefore, that the heat of India is increased by the burning of cattle-manure, the soil losing the advantage of the moisture-holding material. In some cases the physical or mechanical effect of dung is quite as great as its directly manurial one. This is not possessed by the ashes, and would be entirely lost in the burning. It is not necessary for me to pursue this further than to say again that the statements made as to the small value of Indian cattle-manure, and the small loss that takes place when it is burnt, are incorrect. My analyses are, of course, those of single samples only, but, they were taken quite in the ordinary course, and are confirmed by Mr. Hughes' results. I am, however, well aware that much more extended work and enquiry than I have had leisure to make are needed before facts are established for India in the same way as they have been in England. Nevertheless, I shall have shown by these examples how very great is the need of careful scientific enquiry in connection with agriculture, in place of the conjectures and theories of the past.

The organic matter is lost, its influence, physical and chemical.

Cultivators do not burn dung for fuel unless obliged to do so through scarcity of firewood.

122. I have spoken of the practice of burning dung as being a general one, and so it unfortunately, is; but it is very far from being a universal practice among cultivators, pure and simple. I would go further, and say that the best cultivators do not burn dung except out of sheer necessity, and because they have nothing else for fuel, and that, even amongst second-rate cultivators, a great majority will not burn dung if they can help it. Perhaps in all my enquiries there was none into which I looked more closely than this, as I had heard and read such diverse opinions about it; consequently, wherever I went, I did my best to inform myself upon it. As the result, I have no hesitation whatever in saying that amongst *cultivators* the reason why they burn dung is that they have no wood; and that if wood could be made cheap and accessible to them, there would be an enormous increase in the amount of manure available for the soil. I can instance place after place which I have visited and where no cultivator burns a scrap of manure for fuel, or where the least possible quantity is so used—generally only a little to boil milk Coimbatore, Salem, Madura, Gujarát (Bombay), Nadiad, Hospet, Hoshiarpur, and Multan are cases in point. It is where, as in the North-West Provinces, wood is dreadfully scarce, that the practice of burning dung has grown into a habit, and I have been told by people well acquainted with the North-West Provinces only, that the people will never give up the practice, and *must* use dung for their cooking. But what I have seen in other parts, where not a morsel of dung is used even for cooking, or for boiling milk, convinces me that, if firewood were provided, the cultivators would soon come to know the benefit of saving their manure for the fields. Those resident in villages, but not themselves the actual cultivating classes, will doubtless continue to burn dung, and near a town there will always be the inducement of realising something by the sale of cow-dung cakes. The seller does not appreciate that the cakes have cost him anything to produce; that they are really his crop taken off his land, and he returns from the town happy with the two annas or so of *ready money* which he receives in return for a donkey-load or head-load of cow-dung cakes. If he buys firewood, on the contrary, he has to *pay* money away instead of *receiving* it. When, however, one gets away from the towns, it will be found that manure is rarely a purchaseable article. The reason why dung is used as fuel for cooking, and especially for boiling milk, is, I believe, that it gives a slow fire which does not need any attention, whereas a wood fire does. There are also ideas that cow-dung imparts to the food a particular flavour which the people like; but, as I have said, there are many places which I have been to where cow-dung is not even used for this purpose. Cow-dung fuel is a handy form in which a Native can carry fire about with him all day long, for it keeps smouldering away gently; wherever matches are unknown, this fact accordingly acquires considerable significance.

Instances in support.

123. I give some instances, from my own observations and from the reports of others, which bear out the opinion I have expressed.

Punjab.

At Hoshiarpur there is plenty of firewood, and comparatively little dung is burnt; the cultivation here is by wells. Visiting Rashida, near Multan, where the Sidhnai Canal comes, I found that the cultivators do not burn dung, with the exception of a little for boiling milk.

North-West Provinces

In the North-West Provinces, as stated, the scarcity of wood is, perhaps, greater than anywhere else, and so the burning of cow-dung cakes has become, from necessity, almost a habit, even among cultivators. But what is more frequently the case is, that for four months, November to February, the *raiyat* makes cakes for burning, and during the other eight months the dung is used as manure. Sometimes I have found that the cakes are made during eight months, and that the manure is used for the fields the remaining four; in each case the rains determine the date, for during the rainy season cakes for fuel cannot be made.

Thus, a cultivator near Cawnpore, belonging to the *chamar* or leather-dresser caste, told me that he made cakes for three months, and collected dung for his fields the other nine months, dating from April 1st in each year. An *Ahir* (goatherd) near Rura made cakes for four months (November to February), but collected manure the rest of the time, except a little which he burnt for boiling milk, and for his pipe (*hookah*); a Brahman here told us that he burnt as little dung as he possibly could. A *Káchhi* at Cawnpore, who had dug a well for himself, and grew vegetables largely, made cakes for eight months in the year, and burnt them, but only because he had to pay so much money for firewood. He was in the habit of buying the stalks of indigo and *arhar* (a pulse) to eke out his fuel, and, in addition, he purchased the town-sweepings to put on his fields.

Mr. Moens, in his Settlement Report of Bareilly, says, "three-quarters "of the available cow-dung of every village has to be consumed as fuel, for "want of wood."

At Rasurpur, near Aima, I found that manure is sold to other villages, but the reason of this is, that the village is a cattle and not a tillage one at all.

Bengal.

Travelling in Eastern Bengal, in the neighbourhood of Serajgunge, I noticed that the general practice among the cultivators was, to have two heaps of dung, one for fuel and one for manure.

Mr. Sen writes of Burdwan:—"In Beerbhoom no good cultivator would "think of using his cow-dung as fuel. Everything of manurial value is "put in the dung-heap." Here there is plenty of jungle.

Reports from Lohárdaga, Palamau, Pichasa, and other parts of Bengal say that dung is "not a marketable article," or is "seldom bought or "sold."

Central Provinces.

I cannot give any instance from the Central Provinces in which dung was not regularly burnt as fuel. But, as it is well known, here, if anywhere, the soil requires no manuring, and one would accordingly expect less care in the preservation of dung.

Ajmere.

At Biawar, near Ajmere, some dung is burnt, and some is kept for manure. The supply of water is, unfortunately, short, and this prevents as much manure being used on the land as might otherwise be the case.

Bombay.

At Ahmedabad, firewood is scarce; it costs R. 1 for four maunds of 40 lbs. each, and the testimony of the cultivators is, that they gather all the stalks, &c. off their fields, and would not burn any dung if they could possibly help it. Poona is another place where firewood is expensive. It has to be carted between 30 and 40 miles, and then costs Rs. 5 a cartload, whereas a cartload of cow-dung cakes costs Rs. 3, and a cartload of loose cow-dung, R. 1 only. It is not to be wondered at, then, that the cakes are burnt as fuel instead of the wood. The general opinion expressed was, that if the price of wood were halved the cultivators would not burn cow-dung, for they fully appreciate its value.

The country around Nadiad is well wooded, and no *Charotar Kunbi* (the best cultivating caste) burns dung, not even for cooking purposes. Manure is sold out of the town to the cultivators, they paying R. 1 for 20 maunds (of 40 lbs. each).

Mr. Beyts says of Gujarát (Bombay):—"Here manures are largely "used. Cow-dung is not burnt."

Madras.

It was, perhaps, in Madras that I found the strongest ground for concluding that cultivators, if they had firewood in sufficiency, would abandon the burning of dung as fuel.

At Avenashi (Coimbatore) the cultivators do not burn dung at all, but, on the contrary, they buy it from the people who keep cattle but have no fields themselves. This is not because of any plentifulness of firewood, but because by growing hedges and clipping them, and by gathering all stalks, &c., the people manage to eke out their stock of fuel without having to burn the dung. No cultivator at Salem burns dung, although those who live in the town and keep buffaloes will make up cakes for burning. The same is the case at Shiyali.

At Hospet there is plenty of wood, and consequently dung is not burnt, except just a little for boiling milk. Firewood at Hunsur (Mysore) has to be carted 17 miles, and costs Rs. 3 a ton besides; this is the sole cause of dung being burnt there.

Mr. Benson says that in some parts of the Cuddapah district of Madras dung is never burnt.

Mr. Nicholson, in his "Manual of Coimbatore," goes into this matter at considerable length, and shows that cattle-dung is *never* used as fuel except in towns, and that Mr. Robertson (Superintendent of Government Farms, Madras) was wrongly informed when, in one of his Reports, he said it was. Mr. Nicholson's remarks are worth quoting:—

"Cattle-dung is *never* used except in towns. Very occasionally a few "*bratties* may be seen in a *bandy-pettah* (a standing or halting place for "carts), but not a hundredth of the cattle-dung is so used, partly because "the value is perfectly known, partly because fuel for the few wants of "the *raiyat* is supplied by hedge and tree loppings, cotton and *kambu* stalks, "and so forth."

"Village sweepings and cattle-droppings are carefully stored; pots and "tiles are burnt with sweepings, stalks, and small wood, but *not* with "*bratties*."

It should be added that cow-dung is used for plastering the floors and walls of houses; also, that a very large quantity is employed, especially on the outskirts of large towns, for brick-burning.

The close connection between the firewood and the manure supplies.

124. The instances here given show clearly how close is the connection between the supply of firewood and the return of manure to the land. As the result of my enquiries, I feel I may safely assert that where the practice of burning dung as fuel prevails among the *genuine* cultivators, it arises, in eight cases out of ten, from the scarcity of firewood. The other causes are, a deficiency of water; the land (as in the Central Provinces and silt-renewed tracts of the Punjab) not requiring manure; and, lastly, bad cultivation, which generally means cultivation by castes agriculturally inferior.

The fuller treatment of the way in which to remedy the loss of manure caused to the land will be taken in the next chapter, but I may, before passing on, say that the only remedy I can see is the establishment of the "Fuel and Fodder Reserves" spoken of in Chapter IV., paragraph 37. Anyhow, there can be but one opinion as to the desirability of lessening the amount of dung burnt. Sir Edward Buck wrote in 1881:—

"It is manifest that in the interest of agriculture every "attempt should be made to minimise the expenditure of "manure as fuel."

Ashes of dung, and their special uses.

125. Ashes of dung have a distinct value on account of their mineral constituents, and they may occasionally be used to greater advantage than the dung itself. When, for example, a forcing effect is not desirable, the ashes are preferred; again, in very wet parts, such as Máhim, the cultivators have difficulty in preserving manure, and the most general use they put it to is to burn it for *ráb** (the system of making seed-beds for rice, &c.). The unburnt manure would possibly, in such a wet climate, retain too much moisture and keep the soil too sodden, whereas the ashes have a reverse effect, and enable the water to drain away better, thus keeping the soil porous and less saturated.

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* *See* footnote, page 27.

Again, it is a question still to be determined satisfactorily, whether in soils like black cotton-soil there may not be sufficient organic matter to render the ashes of dung as effective as the dung itself.

I mention these points in suggesting a field of enquiry in which agricultural chemistry can do much good by explaining what does actually take place.

But, that the cultivator, when he does prefer ashes to dung, or else the whole dung to the mere ashes, does so simply from fancy or from ignorance, I am by no means ready to allow, but assert that quite the contrary is the case. A cultivator from Tinnevelly, whom I interviewed, described to me his practice thus:—"I would use ashes for my nursery beds, and raw "dung to get 'produce.'" He added that for heavy land he would use the raw dung, and the ashes for his lighter land. This use of dung for opening heavy land quite agrees with English experience. At Madura the cultivators said to me "the Native "knows the unburnt dung is better; there is more 'force' in "it." I often think of the answers given to me by two cultivators, one at Salem, the other at Avenashi, when, after they had complained to me of the difficulty of getting firewood, I said to them, for the purpose of testing them, "But why don't "you make the dung into cakes and burn them? Then you "have the ashes left; what more do you want?" The one replied, "What is that? It's only a little; that's not enough." The other said, "If I burn the dung what shall I have for "manure? How can I live if I burn my cattle-dung? I "want it all for my garden."

I pass on now to consider other modes of manuring the land.

Sheep-folding.

126. Folding of sheep and cattle on land, for the purpose of manuring it, is another practice understood in some parts, but neglected in others. It has one great advantage, in that the urine is not lost, as it generally is. Folding is practised largely in Coimbatore and other parts of Madras; in the North-West Provinces; in Palamau and Rungpore in Bengal (chiefly for sugar-cane and tobacco crops); at Rawal Pindi (Punjab), and elsewhere. Sheep and goats are generally used, but cattle are not unfrequently tied outside the pens also, and fodder [principally *chólam* (a millet)] is given to them. The animals are allowed to graze by day over the dry fields, along roadsides and wastes, picking up whatever they can, and at night they are brought into the pens. The pens are moved about every second day. The cultivators pay for the privilege of having the sheep go over their fields, thereby manuring the land. In Tinnevelly, sheep are bred largely, and chiefly with the object of using them for manuring the land.

Refuse from oil-seed crushing.

127. Perhaps next to, but insignificant as compared with, cattle-manure, is the use, as a manurial agent, of the refuse obtained from various oil-seeds after the oil has been expressed from them. The principal oil-seeds thus used are the following:—Castor-oil seed (*Ricinus communis*); Gingelly, *Til*, or Sesame (*Sesamum indicum*); Earth-nut or ground-nut (*Arachis hypogea*); *Kardai* or Safflower (*Carthamus tinctorius*); Rape seed; Mustard seed; Niger seed (*Guizotia abyssinica*); Linseed; Cotton seed. The seeds of the fruits of several trees, such as *Pongamia glabra, Bassia latifolia* (the *Mahua* tree), and *Melia Azadirachta* (the *Neem* tree), are also pressed, and the refuse is employed as manure, chiefly in the coffee districts. Most of these seeds, after expression of the oil, are also used primarily for feeding cattle, and secondarily for manure.

Castor cake.

Castor-oil is a plant grown very largely in Gujarát (Bombay), and it is a common sight to see it fringing the fields in the North-West Provinces, also in Bombay and Madras. In Máhim, where, in consequence of heavy and continuous rain, it is hard to preserve cow-dung, castor refuse, obtained from Gujarát, is used to a surprising extent for the more expensive crops. Thus, for *betel* vines, from 9 to 12 tons of castor cake per acre, costing Rs. 280 to Rs. 380, will be carefully applied in handfuls round the base of the plants, in some 15 to 20 separate doses; for ginger, sugar-cane, and plantains, lesser amounts, but still costing from Rs. 60 to Rs. 160 per acre, are used. Castor refuse is also employed at Poona, Burdwan (Bengal), Hoshiarpur (Punjab), and elsewhere, but in many places it is merely thrown on manure heaps or else burnt as fuel. Its cost varies from Rs. 20 to Rs. 35 a ton. An extensive use for it is found in the coffee-growing districts of Coorg and Mysore, where it is known as *castor poonac.*

An analysis which I made of a sample of *castor poonac* from Mysore showed it to contain—

	Per Cent.
Nitrogen - - - - - -	4·52
equal to Ammonia - - -	5·49
Phosphate of Lime - - -	2·86

Accordingly, it possessed manurial properties of decided value.

Other cakes.

Gingelly cake is often fed to cattle, and is also exported. Earth-nut is grown mostly in Madras, and especially in South Arcot; it goes mainly for export. Rape seed and Mustard seed are similarly exported. Niger seed is not largely grown, but yields a good burning oil, and the residue is used as food for cattle. Linseed is almost entirely an export crop. Cotton seed is generally fed locally to cattle. The other seeds mentioned have mostly only a local significance; but from the flowers of the *Mahua* tree (*Bassia latifolia*) a spirit is obtained by distillation, the spent material being used as food for cattle. The fruit of the *Mahua* tree, when allowed to ripen, contains a hard seed from which a valuable oil is expressed, and the residue is used as manure under the name *Bassia* cake. For the particulars given as to the various oil-seeds I am mainly indebted to Dr. Geo. Watt. Analyses of several of the varieties of cakes are given in the Appendix.*

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* *See* Appendices J. and K.

The effect of export of oil-seeds on the soil's fertility.

Now it is clear that, as these seeds are for the greater part exported, their export must imply the removal of a very considerable amount of the constituents of the soil. Were they (with the exception of castor-oil seed) to be consumed by cattle, after expression of the oil, the manurial constituents would be returned to the soil from which they were drawn, and the balance of fertility might be maintained. The oil, having itself no manurial properties, and being derived from the atmosphere and not from the soil, is a fitting object for export; but to send away the entire seed, or the refuse after removal of the oil, is to send away the valuable manurial constituents contained in the seed, including those taken out of the soil itself; in brief, to export them is to export the soil's fertility. The answer given will doubtless be that there is the advantage of the *ready cash* obtained in exchange; but it becomes the duty of Agricultural Departments, and of Experimental Farms in particular, to demonstrate clearly to the people what the advantages are of using such refuse materials, either as food for cattle, and thus indirectly as manure, or else by direct application to the land. Where, as in India, supplies of manure in any form are so short, it seems wrong to allow so much manurial element to be carried beyond the seas, without endeavouring to establish its value and the importance of retaining it in the country. We in England are not slow to avail ourselves of the advantages this export system offers; and at the time of my leaving for India I was feeding bullocks at the Woburn Experimental Farm on linseed cake, and was also growing crops with rape cake manure. Both these materials, in all likelihood, were the produce of Indian soil, and represented its transported fertility.

Seet, or Indigo refuse.

128. *Seet*, or Indigo refuse, consists of the leaves and stalks of the Indigo plant after they have been steeped in order to extract the colouring matter, and is largely used in the Indigo districts of Behar and Bengal by the planters, being, practically, the only manure they employ. Where, as in Madras, the North-West Provinces, and the Punjab, the manufacture is mostly carried on only on the small scale and by Natives, the *seet* is purchased by the ordinary cultivators, and they spread it on their fields. A great deal is so used in the Cuddapah district of Madras. A field thus manured is considered not to need any more manure for the next three years or longer. I saw, near Cawnpore, a splendid field where wheat was growing on land thus treated, and experiments conducted at the Cawnpore Experimental Farm have shown the benefit of the refuse. The cultivators do not like the *seet* when new, but prefer it when nearly two years old. At Rura, near Cawnpore, I found that the landlords (*zemindars*) were in the habit of manuring the fields with the *seet* at their own expense, and then letting them out to cultivators at a high rental.

Green-manuring.

129. Next to be considered is green-manuring, a practice not unknown, but yet not nearly as widely distributed as it might with advantage be. *San* or *tág* hemp (*Crotalaria juncea*) is the crop most generally ploughed in; indigo is another; mustard is occasionally used; and frequently on rice fields the weeds are allowed to grow, and then turned in to act as manure. In Lohardaga the favourite green crop is *sáwán* (a wild form of *Panicum miliaceum*); it is often grown with rice, and after the rice has been harvested the green crop is turned in and buried in the soil. Green-manuring is well understood in some parts; for example, in Gujarât (Bombay). It is also practised in Hoshiarpur, Burdwan, Hooghly, Chota Nagpur, Poona, and parts of Khândesh. *San* ploughed in as a green crop, in preparation for sugar-cane, is the usual form of green-manuring. In other districts, such as Bareilly (North-West Provinces), green-manuring is quite unknown; in Coimbatore too, so far as the actual growing of green crops is concerned; whilst in many parts of Bengal its use might be more extended. Mr. Moens says of Bareilly, "The benefit of ploughing in a green crop is quite unknown "here." Experiments made at the Bhadgaon (Bombay) and Cawnpore (North-West Provinces) Farms have demonstrated the advantages of ploughing in green crops such as the *san* hemp or indigo.

Use of twigs and leaves as manure.

130. Over a large part of Madras, Coimbatore included, the spreading of wild shrubs such as wild indigo (*Wrightia tinctoria*), *madar* (*Calotropis gigantea*), *avarái* (*Cassia auriculata*), *kolinji* (*Tephrosia purpurea*), convolvulus, and the shoots and leaves of *Pongamia glabra* and other trees is much used on "wet" lands, principally on rice fields. The shrubs and leaves are spread green on the fields, and then trodden in by foot. At Hospet, which is served by a canal, led by a weir or *anicut* from the river Tungabadra, and where the cultivation is exceptionally good, I saw this plan of green-manuring being carried out. Trees are grown round every field and along the banks of the water-channels, and are defoliated once in three years; the twigs and leaves are spread on the land where rice is to be sown; canal water is let on, and the twigs are trodden into the soil with the foot. About eight days later, rice is sown broadcast on the top. It is worthy of note that, though served by canal irrigation, the compartments or beds in which the water is enclosed are here quite small, just as in "garden" cultivation.

The practice of putting twigs and leaves on rice fields is largely adopted in Tinnevelly. Branches and leaves are used as manure near Bangalore in April, and at the end of the monsoon. When touring in the Suni Valley (Punjab) Dr. Watt pointed out to me a shrub (*Adhatoda Vasica*) which acts as a weed-exterminator; the natives spread it, when green, on their rice fields, and it is said to kill all the weeds in 24 hours. At Máhim the leaves of the sugar-cane are spread on the ginger-beds to act as manure; leaves are also put round the plantains. Near Rura (North-West Provinces) I saw a cultivator using leaves as manure on his opium beds, and he thought very highly of them. In the Forests of North Kanara and along the Malabar coast leaves are gathered and used as manure. Leaves are, generally speaking, collected in the neighbourhood of towns and villages for the purpose of "parching" grain.

I believe that in these various ways of green-manuring, the *physical* improvement of the soil is an important point. At the same time it shows that the value of vegetable matter, as an addition to the soil, is not neglected by the *raiyat*, although some would maintain that its loss in the burning of cow-dung is of no account.

The *ráb* question.

131. Associated with the use of twigs, leaves, &c. for manure is the system of seed-bed cultivation termed *ráb*.* This system is employed mainly in the Bombay Presidency throughout the districts of heaviest rainfall, but it is not unknown in parts of Bengal. The crops for which it is chiefly used are rice and a millet called *nágli* (*Eleusine Coracana*). The word *ráb* literally means "cultivation." The process consists in heaping on the spot selected for the seed-bed successive layers of cow-dung, tree-loppings, shrubs, leaves, and grass, with earth on the top to keep all down; the heap is made about three feet high, and then the whole is set fire to.

Mr. Ozanne's experiments in Bombay.

As regards the advantage, still more the necessity, of *ráb*, there have been continuous contentions between the cultivators and those who have supported them, on the one hand, and the Forest Department on the other, the latter maintaining that the practice is a wasteful one, and that the lopping of trees injures the forests greatly. In 1885 a Forest Commission was appointed in Bombay to enquire into the matter, and Mr. Ozanne, Director of Land Records and Agriculture, Bombay Presidency, conducted a number of experiments, which, though not absolutely conclusive nor complete, went far to show that the *raiyat* in *ráb* areas was adopting the only ready means by which he could cultivate his rice crop with profit. Great credit is due to Mr. Ozanne for the energy which he showed and the line of enquiry he adopted. He pointed out that there are defined limits to *ráb* cultivation, viz., the districts where rainfall is very heavy and also continuous. For example, *ráb* exists in the Konkan, whereas in Dhárwar, where the rainfall is less heavy, it does not. Similarly, *ráb* is not used where there is tank irrigation, for by the aid of the tank the seed can be sown before the heavy rains come. Mr. Ozanne's experiments also showed that brushwood and shrubs when used as *ráb* material give just as good results as boughs of trees do, and that there is nothing in the *raiyat's* belief in the superior virtues of particular kinds of trees. Cow-dung (which the *raiyat* prizes most for *ráb*) gave the best results of all; the supply of it is, however, limited; but, with the aid of brushwood, shrubs, and grass, the cultivator can make up the necessary amount for burning. In this way the Forests had, up to the time of the enquiry, been of great use to agriculture.

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* *See* footnote, page 27.

It is undisputed that *transplanted* rice gives far and away the best return, and that only the finest kinds of rice are so sown. At Igátpuri, where, owing to scarcity of *ráb* material, a good deal of rice is grown from "sprouted" seed (the seed being allowed to soak for two days in water before sowing), the out-turn is not so good as at Kalyan where *ráb* prevails. If seed is "sprouted" and sown, but the rain does not then last, the seed is wasted, but *rábed* seed is not put in the seed-bed until the rain actually comes. The assessment of the land has of late been lowered at Igátpuri, on account, it is believed, of the difficulty in getting *ráb* material, and the consequent lesser yield of rice. Rice, though aquatic, cannot stand immersion, and it is noticeable that where *ráb* is practised the seed-bed is always on elevated ground. Rice cannot be sown in the wet, as it would rot; this accounts for *ráb* being used at Máhim, inasmuch as, apart from the difficulty of preserving the cow-dung in such a wet climate, if it were put on the seed-bed it would tend to hold the moisture all the more. By burning the dung on the land a drier and more porous soil is obtained.

The advantages of *ráb*.

At first sight, I allow, one would conclude that the practice must be a very wasteful one, but the fact that it is carried on by *raiyats* such as those at Máhim, the excellence of whose cultivation excited my highest admiration, obliges me to conclude that, though I cannot explain *why* it is, yet *it is* the *one* way in which the cultivator can grow his rice to best profit. I cannot believe that men who annually spend such large sums as these cultivators do in the purchase of castor refuse, &c. would burn their cow-dung for *ráb* if they had not found out by experience that it was the best plan to adopt. In other words, I am content to learn from practical experience, and to endeavour to explain the science from the practice.

Possible explanation.

It is not at all unlikely that much of the benefit of *ráb* is due to the change produced in the mechanical texture of the soil by the burning which it undergoes. This results in the liberation of some of its dormant constituents, and the supply of ready-formed food for the plant, which, at this stage, needs to be quickly forced on; then, again, the addition of mineral matter from the materials burnt must conduce to the richness of the soil, and, while supplying plant food, would, at the same time, render the soil porous, so that it would not retain excessive moisture, as might be the case were natural manure or green leaves to be used. There is a further possible benefit in the destruction, through burning, of any weed seeds which might choke the rice in its early stages. I find it stated in the Lohardaga Agricultural Report that:—

> "for paddy nurseries, in many parts the manure heap is set on fire "first, the motive being to kill grass seeds, which, where the soil is poor, "would germinate and kill the rice; but this is not done in Five Parganas, "since the land is fertile there, and the young crop grows up strongly "enough to keep the weeds in check."

This instance from Bengal may afford a possible explanation of what takes place in other parts. The whole subject of *ráb* is an interesting and important one, about which there is still much to be learnt, and on which the scientific agriculturist may usefully work.

Manuring by silt, or by soil-mixing.

132. Another system of manuring is that by using silt, tank mud, &c., or by the mixing of soils of different character, in order to improve the texture of the land.

Silt from rivers, streams, and canals.

Vast areas in Bengal are annually renewed naturally by the silt of rivers, and there are in the Punjab, for example, near Gújrat, stretches which are covered yearly by the silt brought down by mountain streams. In the Jhelum and Shahpur districts, at the foot of the Salt Range, there are similar tracts; here the fields are first embanked, and then the flood water of hill torrents is turned into them through an opening in the upper end of the embankment. The water is allowed to flow in until the field is converted into a pond. When this dries up, a crop is sown, and requires no further watering or rain. In this way the wheat-growing areas of these districts are formed, and no manure is used or needed, the coming of the silt supplying more fertilising matter than many manurings could.

In Behar a large proportion of the land is inundated, and the soil is washed from the higher to the lower land, the latter consequently not-requiring manure.

Jute-growing in Eastern Bengal is carried on by the annual renewals of silt from the rivers, and where it comes no manure is needed at all.

It is found that wherever there is silt the *raiyat* does not value ordinary manure or take trouble in preserving it; he looks for the silt to come instead.

In the case of silt-laden canals one reason for the excessive use of canal water is, that the more water that is used the more silt is there deposited, and the people alongside canals have been known to cut the banks in order to get the silt on to their lands. The use of canal silt for growing trees on salty land (*usar*), and for reclaiming the latter, has been mentioned. (*See* paragraph 75.)

Great distinctions are drawn by the cultivators between the rivers and canals which bring silt and those which do not. Thus, the Sutlej is a snow-fed river, and brings sand rather than mud; the silt of the Jumna is considered fertilising, that of the Ganges is not.

Soil-mixing.

The rich soil dug out from tanks is widely appreciated throughout Madras, and in Coimbatore I have seen "soil-mixing" going on, a lighter and red soil being mixed with a heavier and black one. At Rungpore in Bengal this is also practised, especially for jute land, the better soil being mixed with the inferior, just as pond mud might be mixed with a sandy soil.

At Nadiad (Bombay) I noticed another kind of "soil-mixing." Here the fields are all surrounded by hedges growing on embankments. When it is required to turn a field into a rice field, the topsoil is thrown from the centre up against the hedge, thus making an embankment; the level of the field is lowered thereby, so that the rain water, when it falls, is held up and soaks the soil thoroughly. When, in turn, the field requires to be manured, the soil is thrown back from the hedge-side on to the field and is spread over it.

Nitre or saltpetre.

133. Nitre or saltpetre (nitrate of potash) is a salt with which the soil in many parts of India is impregnated, and the manufacture of nitre, together with some common salt, by a somewhat crude process of extraction and purification, may be seen very frequently. Though the manufacture is widely distributed, it is in Behar and the North-West Provinces that most nitre is made. The earth around the remains of old villages is specially found to be thus impregnated. The accumulations of the salt in all probability have their origin in the natural process of nitrification (production of nitrates) which the solid and liquid excreta of cattle and men, as well as vegetable and other refuse, have undergone. Wood and other vegetable ashes supply potash in the form of carbonate of potash, which then combines with the nitrates, producing nitrate of potash. The potash in the soil itself, more especially when the soil is clayey in nature, no doubt, contributes also to the production of nitre. This explanation accounts for the nitre-containing earth being found mainly where habitations formerly stood.

Its method of formation.

The men who manufacture the salt know by tasting the earth whether it will pay them to work it or not.

Nitre as a manure is but little used, owing to its high price. Experiments at Government Farms have shown that it gives a considerable increase in the out-turn of cereal and other crops; but these experiments, like several others, have not been conducted with a view to seeing if the extra return would pay for the expenditure, and if there be a likelihood of the *raiyat* availing himself of the manure. The price of crude saltpetre varies in Behar from Rs. 1. As. 8. to Rs. 3 per maund (of 80 lbs.), but the lower-priced kind would be very impure. Generally speaking, it may be said that its cost locally is Rs. 2½ to Rs. 3 per maund of 80 lbs. This is the price at Cawnpore; also at Salem (Madras). In Gujarát (Bombay) nitre costs nearly Rs. 5 for the same weight; and delivered at Calcutta, the price is from Rs. 5 to Rs. 6½, according to quality.

Price.

The price of saltpetre, accordingly, puts it quite beyond the reach of the ordinary cultivator, and it is only in the case of crops which bring in a large monetary return, such as sugar-cane, coffee, tobacco, opium, and indigo, that it has any chance of being used in the country. Thus, it becomes almost exclusively an article of export, principally to the United Kingdom. In Coorg, among the coffee planters, a small amount is used as manure. Occasionally, too, the Natives will use the nitre-containing earth itself as a manure,

Use as manure.

spreading it round the base of the sugar-canes, &c. I saw the earth being used for canes at Hoshiarpur, and also for wheat at Hissar. An efflorescence of nitre often appears on the walls of houses in villages of the North-West Provinces and Oudh, as well as on the earth around them; it is then scraped off and used as manure.

Well waters containing nitrates.

Reference has been made in the last chapter (Chapter VI., paragraph 99) to well water which is termed *khara* by the cultivators, and which is held in special repute for tobacco-growing. Nitrates, as I have shown in the analysis there quoted, hold a very prominent place in the composition of such waters, although, in that instance, rather to my surprise, I found that they existed as *soda* and not as *potash* salts. It is quite possible that nitrate of potash occurs in other cases, but the subject needs more complete investigation. In another instance, when at Avenashi, I noticed a white crust on the soil, and the cultivator said that it was prejudicial to his sugar-canes; he added that it came from the well water. He did not grow tobacco here because the water was not of the *kind of brackishness* he liked. As far as I could tell from a cursory examination, the saline crust on the soil was sulphate of soda, but whether it came from the water or from the soil no one could tell me. I only mention this to show that the Native clearly discriminates between the properties of different waters, though he does not know whence they arise, and also to show the amount of useful work that could be done by a chemist who would investigate these various points.

Wood ashes.

Other sources of potash are wood ashes and the ashes from burnt cow-dung cakes; these, as we have seen, are not wasted, but generally find their way on to the manure heap.

Lime.

134. Lime is seldom, if at all, used as a manure. Nor, as we have seen in Chapter V. (paragraph 63), is its use generally required, the soils of India, as a rule, containing a sufficiency. Were there to be need of its special application, an abundant supply would be found in the concretionary limestone known as *kankar*, which in so many parts underlies the soil.

Kankar.

Gypsum.

A further supply of lime, in another form, is available from the vast beds of gypsum (sulphate of lime) found in the Salt Range in the Punjab, which are capable of supplying almost inexhaustible quantities of lime. Some experiments that have been carried out seem to point to the possibly profitable use of gypsum as a manure for indigo, and support for this may be found in the known value of gypsum as a manure for clover. Indigo, like clover, is a leguminous plant. It is on the laterite soils of Coorg and Mysore, as also in the Neilgherries, that the lack of lime in the soil is felt, and here its application separately would, I am confident, be beneficial. Mr. Elliot, of Munjerabad, reports to me that lime, where put on, has done good. Unfortunately, it is in these parts that lime is hardest to procure. In Coorg and Mysore a compost for coffee is made out of the pulp from the coffee berries mixed with lime, soil, &c.

Phosphatic manures.

Few mineral sources discovered.

135. Bones are practically the only source of supply of phosphates to the soil. Small quantities of apatite and phosphatic nodules were found by Dr. Warth and Mr. Parsons at Mussoorie (North-West Provinces), in 1884, and by Dr. Warth, in the Eocene of the Eastern Salt Range. Coprolites have been discovered in spots in East Berar and the Upper Godaveri district in Hyderabad, but nowhere in anything like sufficient quantity to be profitably worked. Nothing else that I know of in the way of raw phosphatic material for manufacture into manures has been found in India.

Fish manure.

Fish manure, which may be considered partly a phosphatic manure, is prepared in parts along the sea coast, such as Mangalore (Mysore), and is transported inland within certain distances, being used almost entirely by the coffee planters of Coorg and Mysore.

I pass now to the more important consideration of the use of bones.

Bones.

136. Bones, as is known, are very extensively exported from India, and are but little used in the country itself. The question whether the export of bones should be allowed to continue without a strong effort being made to retain this source of manure in the country, has been prominently brought forward of late years, and the Government of India recently caused enquiries to be made as to the trade in and use of bones. The general reply received was, that the export was an increasing one; that the trade was carried on entirely by European capital, and that the actual collection of bones was done by Muhammadans and low-caste Hindus; that it was principally confined to districts served by railways, and from villages within an easy distance of the line; and, lastly, that bones were not used by the native agriculturists. It is estimated that 60 million cattle die or are slaughtered annually in India. The export of hides and skins amounts to over 30 million yearly, though the number is not an increasing one, for more raw hides have been used in the country itself of late. In 1888–89, as also in 1889–90, 6½ million raw hides were exported from India to foreign countries, 1½ million dressed hides, 4 million raw skins, and 19 million dressed skins. Whether taken from the number of hides or from the estimate of the cattle that perish, it is evident that there must be a very large supply of bones available. Hindus, however, being largely a non-meat-eating people, and regarding the bones of cattle as those of their ancestors, and hence sacred, are prevented by their caste prejudices from collecting or utilising the bones. Ninety per cent. of the Hindus may be said to be non-meat-eating, and, of the remaining 10 per cent., fully 5 per cent. cannot afford to get meat. The consequence is, that the bones are left lying about wherever the animals may happen to die, or are thrown into ditches (*nullahs*) and ravines and left there. It has also to be remembered that Indian cattle are less hardy in resisting disease than European cattle, and, consequently, may drop off in great numbers when an epidemic breaks out. Within the past fifteen years a large trade has sprung up in the collection and export of bones; it has increased and is still increasing. Almost the whole amount collected is sent to the United Kingdom, where the use of bones, either raw or else manufactured into artificial manures, is valued highly. The exports of bones from India have been, in round numbers, as follows:—

Amount exported.

Year.	*Tons.*	*Year.*	*Tons.*
1884–85 - -	18,000	1887–88 - -	26,000
1885–86 - -	22,000	1888–89 - -	35,000
1886-87 - -	18,000	1889–90 - -	44,000

Of this total, above one-third goes from Bombay, somewhat less from Karachi, and almost all the rest from Bengal (Calcutta). Madras exports only a small amount, and that mainly to Ceylon. The total value of the exports in 1889–90 was Rs. 24,27,489. Out of the 44,000 tons exported in 1889–90, close upon 40,000 tons went to the United Kingdom, and 2,200 tons to Ceylon. Thus, the trade may be considered one almost entirely with the United Kingdom, and yet, despite this large influx of bones, it amounted, in 1888, to only about one-fourth of the total amount of bones used annually in the United Kingdom.

For the statistics here given I am indebted to Mr. J. E. O'Conor of the Finance Department, Government of India, and to Mr. H. Voss of the Anglo-Continental Guano Works, London.

The collection of bones.

The collectors of bones are mostly coolies of the *Chamar* caste. The bones are roughly broken with a hammer, conveyed to the nearest station, and there left for removal by train. Bones may be seen lying in heaps at a great number of the stations along the railway routes and waiting for removal to Calcutta, Bombay, and Karachi. Villages within a 10-mile radius of the line have been already cleared of any accumulated stores of bones, but collection of fresh bones goes on, although it does not as yet extend much beyond this limit. The collection of bones is thus a limited one, but, as railway facilities increase, so will it spread. In Bengal, where a damp, hot climate prevails, bones seldom lie long on the ground, but disappear within a couple of years; in the hot, dry plains of the North-West, on the other hand, they get desiccated and bleached, and may thus last a long time and accumulate. Those accumulated stores, however, have now, for the most part, been already carried off.

What prevents bones from being utilised in India?

137. I will now consider what stands in the way of bones being utilised in India for agricultural purposes.

(*a*) prejudice.

In the first place comes caste prejudice. The influence of this, however, will gradually break down, and, before long, the cultivator will not scruple to use bones if he finds it to his advantage to do so. In the business office of a bone-exporting firm I myself saw the different samples being handled by a Brahman.

Secondly, the value of bones for agricultural purposes (*b*) their value not definitely shown.

has not been definitely shown as regards India. It seems hard to believe that there should so long have been this available source of manure, and yet that the *raiyat* everywhere should have been quite ignorant of its use. He utilises most of the materials that he has at hand, and even as regards those which prejudice has prevented him from using largely, night-soil for instance, he is perfectly well aware of their fertilising value. But it is not so with regard to bones; nor have the experiments conducted on the Government Farms at Cawnpore and Nagpur succeeded in establishing the value of bones, nor in showing that it would pay the *raiyat* to collect and use them. I do not say that the enquiry is complete, but it is clear that the benefit of bone manures is not of the marked nature in India that it has been found to be in some parts of England. When looking for a possible explanation my attention was drawn to analyses of Indian soils. As I have pointed out in Chapter V. (paragraph 65), these, as a rule, contain considerably higher percentages of phosphoric acid than most English soils do. Now, phosphoric acid in the form of phosphate of lime is the chief ingredient of bones, and the one for which their use in agriculture is prized. Again, it is necessary to point out that bones, or even bone manures, are not of *universal* benefit even in England; on *some* lands, and in certain parts of the country, there is nothing that does so much good; in others they and the money paid for them are thrown away, and quite as good a result would be obtained by using the cheapest mineral superphosphate. No practical farmer and no agricultural chemist has ever yet been able to determine exactly why or when this is the case; but it remains a fact that the application of bones has really to be made experimentally at first in order to see whether they do good; then, if they do, they generally pay well. But each man has to get to know his land, and to learn by experience whether bones are good for it or not.

(*c*) difficulty of collecting and keeping.

Now let us take the practical difficulties apart from caste prejudice, and let us suppose for the moment that the value of bones in India had been proved. The whole export is little more than one-fourth of what the United Kingdom annually requires. What would this amount to, therefore, if spread over the whole of a vast continent like India? It would not be much more than a drop in the ocean!

Again, while it may pay a trading firm to send out collectors of bones, it does so only along rail-served tracts, and within a certain radius. We have to see how the *raiyat* would be affected. The death of one of his cattle is, happily for him, not an every-day occurrence, and, when it does happen, it is only about 20 seers (40 lbs.) of bones that are yielded. What is the *raiyat* to do with these? Is he to store them until another of his cattle dies, and so on, until enough are accumulated to make it worth his while to break them up and manure a field with them? Or is he to roam over the wastes and ravines and pick up single bones? If the use of bones is to be general, there would be others doing what he does, and how far would the bones go then? He would, again, find himself in competition with the paid agents of exporting firms, as soon as the extension of railways or the difficulty of getting a sufficient supply of bones near at hand had obliged the search to be made further abroad. It must come to it, I think, that the most that the *raiyat* will do will be to throw the bones on to his manure heap, even if he takes the trouble to do that.

(*d*) difficulty of preparing bones for use.

Next, there is the difficulty of preparing bones for use. Suppose the *raiyat* were to collect a sufficient supply and to keep them separate, how would he prepare them for use? Some kind of grinding is necessary, or the bones could not, so experience tells us, be used to advantage. Unless bones be ground to a coarse meal, it is impossible to secure their proper distribution over the area to be manured, nor can the forces of nature so easily act on them and disseminate them throughout the soil as plant food. The old idea in England was, that bone was a capital manure because it *lasted* well, especially if after a number of years a piece of bone could still be found in a field: this idea, has, very rightly, given place to the more scientific one, that a profitable return must be the one which is readily reaped in the crop and not merely stored up in the earth. Accordingly, the *fineness* of agricultural bone-meal is now insisted upon. The *raiyat*, however, cannot afford to pay for a bone-mill, and he has no really available means for reducing the bones to a small size. On two occasions I have seen bones being broken up by hand; this happened on the estate of Mr. Sabapathi Mudliar at Bellary, and at the Seebpore Experimental Farm, Calcutta. At the former place women were employed in pounding the bone, and I was told they would make 100 lbs. of bone into meal in a day. At Seebpore three men using a *dhenki*, or kind of lever hammer worked with the foot, made 20 seers (40 lbs.) into meal in 5¼ hours. It is possible that if the value of bones be clearly shown, the *native cultivators* may begin to break up the bones that lie near at hand, but that the practice will become a general one, or that, if a general one, it will be capable of supplying the manurial requirements of the land to any great extent, I am inclined to doubt.

Prospects of bone being an object of sale in India itself.

It has been suggested that bone-mills might be started up-country, and the bones be sold to the *raiyat* rather than sent for export; but then comes in the *raiyat's* difficulty, his want of capital. He has seldom money to *pay* for manures, especially those the value of which he is not convinced of. And, in any case, the whole matter would be one of *market considerations*. If there is a constant and increasing demand for bones, the price of which in Calcutta is now from Rs. 40 to Rs. 45 a ton (say 3 *l.* to 3 *l.* 15 *s.* a ton), they can only be kept in the country if those who are likely to use them are willing to pay as much as this or more; and where is the money to come from? A tea planter, or a coffee planter, perhaps, may find it worth his while to purchase bones; but it is only crops that yield a high return that will justify their use. In such cases the planters generally have their own bone-crushing mills worked by steam; but, even in the midst of the indigo cultivation of Behar, I met planters who regularly collected and bagged bones for export, finding it more profitable to do so than to grind them up and use them on their land. Railways will not do so much to distribute bones as to afford an outlet for them; in other words, they will facilitate the export.

It is necessary to add one caution more,—as the demand for bones for export purposes increases, it will afford another inducement to the professional cattle-stealer and the cattle-poisoner. Already the hide is an attraction, the flesh is rapidly becoming one also; if to these are superadded the bones, more care will have to be taken in the future to protect the cattle of the country.

The use of bones in India a matter of market considerations.

The whole question of the export of bones is, therefore, I hold, under existing circumstances, one purely of *market* considerations.

Artificial manures.

138. The next subject, that of imported manures, which in an account of English agriculture would fill a most important place, may, so far as India is concerned, be very summarily dismissed. If natural manures, such as bones, are not yet likely to be used, still less so are artificial manures. Not only have no sources of the raw material been discovered which would pay for working, but the acid (sulphuric acid, or oil of vitriol) required for their manufacture, costs, at present, far too much. Over and above would be the cost of carriage both of raw and manufactured material. Once, again, the real difficulty comes in, who is to pay for these? Only crops giving a high return could possibly meet the outlay, and, owing to lowness of prices for produce, the tendency among planters towards economy in artificial manures has of late been marked. The day is still distant, I believe, when artificial manures can be profitably used in India. Some great change, either in the cost of manufacture or in the condition of the agricultural classes, must take place first. A leading firm of chemical manure manufacturers told me, before I went out to India, the result of their efforts at introducing artificial manures into Russia and the East. The only manure which they succeeded in getting into use in Russia was the cheapest mineral superphosphate, and then only in the enlightened Baltic Provinces, where the farmers were, for the most part, Germans. While, however, there may be no immediate opening for artificial manures, it behoves those concerned in agricultural welfare to be on the watch for any developments that may take place. For this reason I consider that the presence of an agricultural chemist would be of service in possibly discovering and in utilising fresh manurial sources.

Adulteration of manures.

139. In connection with the extended use of manures, whether for employment in the country or for export, it is well

Bone-meal

to point out that the practice of adulteration has already been introduced. This is the case with bone-meal. For the purpose of competing against the well-known firm, Messrs. Croft, Wells & Co., some of the native Hindu and Parsi merchants resorted to the mixing of bone-meal with shell-sand, lime, and similar cheap materials. After inspecting Messrs. Croft, Wells & Co.'s bone-crushing mills at Thána, near Bombay, I was taken to the Mazagon Dock, Bombay, where, at and around the landing-stage, were several small establishments belonging to native merchants, and provided with bone-crushing machinery. At some of these works I saw heaps of the shell-sand, lime, &c. referred to, and of the bone-meal to which these were added. I was enabled to get samples of the materials so used, and I give analyses of them in the Appendix.* They consisted, in one instance, of shell-sand, in a second, of burnt magnesian limestone, or substances akin to it. Naturally, a business such as that which Messrs. Croft, Wells & Co. carry on will have its imitators, and unfair dealings may be used in the competition. In this way the reputation of Indian bone-meal as exported to England may be prejudiced, in the same way as that of Indian wheat has been. It is only, however, by purchasers insisting on receiving a definite guarantee of composition and purity, that security in transactions can be obtained.

Oil cakes.

The adulteration of wheat and oil-seeds will be considered later on, but, so far as my acquaintance went, bone-meal was the only *manure* which I found to be adulterated. It is well known, however, that rape-cake, when obtainable in England, is almost always mixed with a quantity of sand and earthy matter, although it is not clear where the actual admixture takes place.

The presence of a chemist would be a means of detecting, and probably of checking, the practice of adulteration.

Points in which the native cultivator does *not* use the manurial facilities he has.

140. Having now reviewed the manurial resources which are in more or less general use, I pass on to consider two main points in which the Indian cultivator does not make full use of what he has at hand. These are, firstly, the non-utilisation of night-soil; secondly, the imperfect conservation of the ordinary manure from cattle.

Importance of the utilisation of night-soil.

141. It is undoubtedly the case that a very great improvement might be effected in Indian agriculture if the system of utilising night-soil, sweepings, &c. were universal. Of special importance does this become in a country which, as we have seen, is too poor to purchase artificial manures, or even to retain in it the bones now sent for export. Still more so when, as in the case of India, not the *crops* alone (such as wheat, linseed, and other oil-seeds) are exported, but also the very *manures* which might be supplied in the refuse from the oil-seeds after the expression of the oil.

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* *See* Appendix

Mr. Nicholson's opinion.

Mr. Nicholson, speaking of Coimbatore, estimates that a population of 1,650,000 persons takes yearly from the soil, for food, 330,000 tons of grain, and a lot of other produce; of this but little is returned to the land. Mr. Nicholson sums up his remarks in terms with which I thoroughly agree :—

> "Every man should void himself on or for his field; artificial manures "are too expensive for the *raiyat*, and he must adopt either the Mosaic "plan or the indirect Flemish, German, and Japanese plan. It is this "manure (night-soil) which enables the Flemings to recuperate their soil."

Sanitation of towns.

I regard the spread of a good system of utilising human and household refuse, street-sweepings, &c. on the land, as a most potent factor in the improvement of Indian agriculture, and having had, among other duties, to enquire into different schemes for town sanitation, I must record my conviction that the *dry* system is the one best suited to Indian circumstances, and that any system which diverts from its proper destination, the land, that which has originally come from it, would be attended by loss to the cultivator and to the State, and would not be satisfactory from a sanitary point of view.

Prejudice is the bar to improvement.

142. Prejudice is the great bar to the proper utilisation of night-soil. It is not that its value is not known, as the appearance of the fields nearest to any village will testify, for the growing of a tall crop, such as *arhar* (*Cajanus indicus*), is frequently a direct indication that that particular field has come to its turn for receiving manure. On these fields the crops are manifestly better than the rest; what is wanted is, greater distribution of these fields. The hope for improvement lies in the gradual breaking down of prejudice. That there are signs of this going on is evidenced by the fact that in certain towns, such as Farukhabad, Cawnpore, and Nagpur, the utilisation of night-soil has had an indigenous origin, and its spread has been due to other cultivators following the example set. It will be, on the one hand, by the force of example, and by the necessity of adopting the most remunerative methods, and, on the other hand, by the breaking down of prejudice through the spread of education, that, by degrees, the ready and natural means of replenishing the land by the use of night-soil will come into general use.

The hope for improvement.

Instances where night-soil is utilised.

143. In a great many towns and villages it is the practice to utilise the sweepings of the houses and streets, but not the night-soil.

I will now instance cases where the utilisation of night-soil has been effected, and where it has resulted in very great agricultural benefit, alike in the well-being of the cultivators, the increase of food to towns and villages, and an increased revenue to the State. These instances will afford evidence of that the capabilities that exist for the improvement of Indian agriculture *from within*.

To take, first, cases where the practice has been indigenous in origin.

Farukhabad. The cultivation around Farukhabad is carried on almost entirely by *Káchhis*. Men belonging to the *sweeper* caste collect and store the night-soil, and the *Káchhis* use it on their fields, putting on as much as 25 tons to the acre. The *sweepers* receive annually as much as Rs. 40,000 for the manure. Land which is close to the site where the manure is stored is assessed at Rs. 20 an acre, that within the manure limit, Rs. 10–12, and land outside at Rs. 5–6, whilst where liquid sewage can be baled out on to the land the rate goes as high as Rs. 30–40. These high values, it should be remembered, are due entirely to the manure, and not to the soil. By its aid three crops a year are grown, first maize, then potatoes, and afterwards tobacco.

(*b*) Cawnpore. From Farukhabad Sir Edward Buck took some of the *Káchhi* cultivators and induced them to settle at Cawnpore. This they did, and introduced their system of cultivation most successfully, so that the value of the land increased rapidly. Only a portion of the original settlement remains, as the land was required for the railway, but what is left retains still the name of "Buck Sahib's" village, and the rent is Rs. 40 a *bigha* (⅝ths of an acre). The *Káchhis* here spend as much as Rs. 40 a *bigha* on the manure, and it is stored in trenches for one year before it is used.

At Nawabgang also, near Cawnpore, I found *Chamar* cultivators using night-soil.

(*c*) Nagpur. Another batch of *Káchhi* cultivators was transferred from Farukhabad to Nagpur, and, as mentioned in Chapter III. (paragraph 27), not only did they continue their special kind of cultivation, but the cultivators around (mostly *Kunbis*), were induced to follow their example, so that now the entire manure from the town is used.

(*d*) Hoshiarpur. At Hoshiarpur (Punjab) night-soil is used largely. When I was there I was told of an action which the *sweepers* had even brought against the Municipality, to prevent their hereditary right to the disposal of the night-soil being taken away from them.

(*e*) Multan. Around Multan, street-sweepings and night-soil are used together.

(*f*) Saharanpur. Just outside Saharanpur I saw the market-garden cultivation carried on by *Sanis*. They use town refuse and night-soil together, spending for sugar-cane as much as Rs. 90 an acre in manure.

(*g*) Meerut. Meerut is another place where night-soil is extensively employed for market-gardening, also by *Sánis* principally. The *sweepers* collect the manure, dig it in trenches, leave it nearly a year, and then the *Sánis* go and fetch it. The price the cultivators pay is Rs. 30 for 20–25 loads, each weighing 10 maunds of 80 lbs. each, which makes the price about Rs. 4 a ton.

The above are, so far as I have been able to separate them, examples wherein the utilisation of night-soil has originated from the people themselves. The instances that follow are those where an extended use of night-soil has been originated mainly by European enterprise.

Amritsar. At Amritsar there is a population of 150,000, involving a gross annual outlay of Rs. 50,000 for scavengering, &c., but no less an income than Rs. 34,000 is received from the sale of night-soil, house refuse, &c., making the net cost of the entire scavengering of the town only Rs. 16,000 yearly. The system was introduced in 1877, and the result is largely due to the energy of Mr. E. Nicholl, the Secretary of the Municipal Committee. Not only this, but the market-garden cultivation that has sprung up around the town, as the joint result of the use of night-soil and the coming of the Bari-Doab canal, is very remarkable. Land will let here for Rs. 30 and Rs. 40 an acre, in addition to canal water charges. The cultivators are mainly *Arains* and *Kumbos* (market-gardeners). It is only in the rains that night-soil has to be buried; at other times the cultivators come and take it away as soon as ever it is brought to the depôts on the borders of the town, and so great is the demand that there is often quite a fight to get it! Dry earth is taken into the houses by the *sweepers*. The cost of the manure is Rs. 5

for a hundred donkey-loads, each load being about 1 maund (80 lbs.). Even the sullage water that passes along the open sewers of the town is, after it gets outside the limits, drawn up by a Persian wheel and is poured on to land. This land is let out at Rs. 42 per acre, including water and the use of the well. What water passes on is taken by cultivators situated lower down a channel (*nullah*), into which the water flows.

(*i*) Poona.

Poona is another good instance of what can be done in an agricultural direction by the use of night-soil. Here the ashes, house-sweepings, &c. are collected, sifted, and burnt; the night-soil is collected separately and put in layers with the ashes, in pits 18 feet × 15 feet and 1 foot deep; 1 inch of ashes is used to every 5 inches of night-soil. After a time, the whole is mixed, more ashes are added, and finally a dry *poudrette* is obtained which takes five days to make in hot weather, eight days in dry weather, and 12 days in the rains. In the rains this work has to be done under cover. There is a great demand for the manure among the cultivators, although seven years ago they would not have anything to do with it. The extensive sugar-cane cultivation around Poona is entirely due to the coming of the canal and the utilisation of the Poona *poudrette*. One half of the entire cost of scavengering the town and preparing the manure is met by the sale of the latter; in 1889–90 it realised Rs. 34,604. The price varies with the demand, but is about Rs. 2 per cartload of 700 lbs., say Rs. 6 a ton.

The urine and sullage water is not utilised as it is at Amritsar, but is allowed to flow into the river. It would be well, I think, both for the sake of the land and also of the river, that a plan such as that employed at Amritsar should be tried. Also, it is clear that the ready way in which the manure is disposed of at Amritsar must save much trouble and the expense of preparation into *poudrette*.

(*j*) Cawnpore.

I have mentioned (paragraph 75) the trenching of night-soil on salty land (*usar*) near Cawnpore. Pits are dug 2 feet deep, and only a light covering of earth is put over it; it is enough, however, to prevent any objectionable smell. Land thus trenched lets for Rs. 45 per *bigha* (⅝ths of an acre) where there is water in addition, and for Rs. 17 where there is no water.

(*k*) Allahabad.

The night-soil of Allahabad is removed by the Municipality, and poured into pits 1½ feet deep, soil being put over the top. Two and a half acres are thus treated every month, and the soil is vastly improved both manurially and mechanically; it becomes quite fine, porous, and open, whereas beforehand it was hard and lumpy.

(*l*) Behar.

I read that four Municipalities in Behar have begun to dispose of night-soil on land, and have realised profits by re-letting the land. In Gya the profit is Rs. 100 to Rs. 150 yearly; in Mozufferpore, Rs. 120; in Buxar, Rs. 84.

(*m*) Madura.

At Madura (Madras) night-soil is mixed along with the town-sweepings in the municipal refuse. The latter costs about Rs. 2½ a ton, and it is reported that the prejudice against it is passing off.

(*n*) Allahabad Grass Farm.

At the Government Grass Farm at Allahabad, land which formerly did not fetch above four annas (one-quarter rupee) a *bigha* (⅝ths of an acre) is now worth Rs. 20 a *bigha*, since it has been trenched with night-soil. Town refuse is also spread to a thickness of three inches as a dressing for grass land, and as many as five cuttings of grass can be obtained in the first year.

Suggestions for village sanitation.

144. At Ferozepore (Punjab) I saw in use the system of sanitation which I consider the best for village latrines. It is the plan of having shifting screens or enclosures, made of bamboo, and within the enclosed area a shallow trench is dug, earth being thrown over at once by the attendant. The screen is moved daily, and in this admirable way the land gets manured evenly and regularly. Subsequently it is ploughed up, and crops (mainly vegetables) are grown.

In regard to village sanitation, a suggestion that is worthy of attention was made recently by the Poona Agricultural

Association. The proposal was, that the rubbish, night-soil, &c. should be collected by village servants, hereditary or hired, and be sold to the villagers as manure, the proceeds going towards payment of the expenses of keeping the villages clean. If there were some system of this kind inaugurated it would soon prove an agricultural benefit.

Where night-soil is to be disposed of to the cultivators, the system in use at Amritsar seems to me to be the very best of all, especially as it provides for utilisation of sullage water, urine, &c. Still, it may not be possible to adopt it everywhere, and the Poona plan of making *poudrette* may sometimes be found the most practicable. If night-soil has to be trenched, I think that there is no necessity for the *deep* trenching so often employed. A depth of 1½ feet of earth, or even 1 foot, is not called for; earth is a capital absorbent and deodoriser of night-soil, and a thin coating of it on the top of the night-soil is sufficient to prevent any smell. If a foot or more of night-soil is put in a trench it is apt to form a scum and to dry on the surface whilst remaining moist below, consequently it does not amalgamate well with the earth. If, on the other hand, a depth of only two or three inches of night-soil be used it is much more quickly incorporated with the soil, and the land is earlier ready for sowing, or for trenching again.

General neglect of use of night-soil.

145. Although the foregoing cases of the utilisation of night-soil have been named, they are exceptional, and there is still a general neglect, throughout the country, of this useful source of manure, one doubly useful because it is at hand and has not to be purchased.

Throughout Bengal, for example, night-soil is, as a rule, not used at all; in Surat (Bombay) and Ahmedabad town-sweepings are regularly used, but not night-soil. Similarly, in Madras I found that at Shiyali, Salem, and Avenashi, only the sweepings were used. In some places there was no one to collect the night-soil; in others, there was a general idea that a crop would not grow with it, though the experiment had never been tried; in others, again, no one would touch the material. In brief, in almost all the villages which I went to, and in whatever Presidency, as soon as I asked the question whether they made use of the night-soil, the cultivators shrugged their shoulders and turned away.

But I believe that, in time, a change will come; and, if reasonable arrangements be made, and the example given elsewhere be wisely enforced, there will undoubtedly follow distinct agricultural improvement.

Imperfect conservation of cattle-manure.

146. The second point in which the cultivator does not make full use of what he has at hand is in the conservation of the ordinary manure from cattle. Excellent as in many respects his cultivation is, yet in his method of securing to advantage the droppings of his cattle, the *raiyat* is, I am sure, greatly at fault. This is, in fact, one of the comparatively few matters which lie close to hand in which he can be shown a better way. Perhaps in no respect has the British farmer of recent years advanced so much as in the economy introduced by the proper making of farmyard manure. The superiority of box-made manure to that of open yards needs no explanation here; the advantage of recovering in the manure the cake which has been fed to beasts is fully admitted, as also the folly of allowing the urine to go to waste. But in India it is quite different; no litter is supplied to the cattle, and not once in a thousand times is any attempt made to save the urine. The solid excrements are picked up, and either made at once into cakes for burning, or else they are thrown on the manure heap, such as it is. The urine sinks into the ground, generally in the hollows worked out by the animals' feet. Now and again a little of the softened earth is scraped away and thrown on the manure heap, but it results in little more than a deeper hollow being made, and serves to expose a fresh surface for the urine to sink into. The value of the urine is, I am sure, not only not fully appreciated, but is actually unknown to a very large number of the cultivators. Did they know its value they might do something more to save it.

The urine wasted.

I give here an analysis of a sample of Urine taken direct from Indian working bullocks, at the same time and under the same circumstances as the sample of dung the Analysis (A) of which is given in paragraph 121 of this chapter, [Table VIII.] For the sake of comparison I give a standard analysis of cows' urine (English).*

Analyses of urine.

TABLE X.

ANALYSES OF URINE from INDIAN BULLOCKS and ENGLISH COWS.

—	F. Urine of Bullocks (Indian).	G. Cows' Urine (English.)
Water and evaporable matters	90·62	91·50
*Solid residue	9·38	8·50
	100·00	100·00
*including mineral matter (ash)†	1·74	
†containing—		
Sand	·01	
Lime	·08	
Magnesia	·57	
Potash	·643	1·60
Soda	·02	
Phosphoric acid	·022	
Total nitrogen	1·168	·90
equal to ammonia	1·418	1·09

Analyses of leaves used for litter.

TABLE XI.

ANALYSES of LEAVES used in MYSORE for LITTER.

—	H.	J.
Moisture	10·73	10·72
*Organic matter	78·44	84·68
†Mineral matter (ash)	10·83	4·60
	100·00	100·00
†containing—		
Phosphate of lime	1·07	·22
Silica	3·53	·04
Potash	·73	1·09
*containing nitrogen	·91	1·18
equal to ammonia	1·10	1·43

REFERENCE.—*Analysis G.*—Johnston and Cameron's Elements of Agricultural Chemistry and Geology, page 321.

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* *See* also Appendix G.

The high value of urine.

Comparing the two analyses of urine, the Indian sample is not inferior to the English, and contains even more nitrogen. Urine contains the greater part of the potash of the total voidings; and, though I do not know the average quantity of urine yielded by cattle in India, it has been found in England that the total amount of nitrogen voided in the urine is from three to four times the quantity contained in the solid excrements. Seeing, therefore, that the urine of animals is richer in fertilising matters than the solid excrements, the loss involved by letting the urine go to waste must be very large. The answer generally given by cultivators when I asked them why no litter was used, was, "We have not enough "fodder for our cattle. How shall we give them any litter?" And yet this is not a real answer, for, when I turned to the manure heap, I almost invariably found in it stalks and straw and leaves, all of which would have done to use as litter. These stalks were thrown in anyhow; so, too, the solid manure; but there was no attempt to make really good farmyard manure out of it, or to let the dung, as it fermented, break down and decompose the stalks and straw and form a uniform mass. Each material was left to itself—the stalks to remain as they were, hard and desiccated, the manure to get dry and to lose part of its value by exposure to the fierce sun during the hot season, or to the heavy rain in the wet season. Had these stalks, straw, &c. been put under the cattle, and been trampled down by them, it would have served to retain a not inconsiderable portion of the urine, and would have made a more uniform material, and one which would have all rotted together afterwards, and formed good farmyard manure. I do not say there is abundance of material for litter in all cases, but there is certainly a great deal that might be utilised. Leaves, for instance, though collected for parching grain, are neglected for litter. Again, if loose earth were sprinkled on the floor, to make up the deficiency of litter, and if this were to be periodically removed, much of the urine could be collected. Waste and coarse grass, shrubs, weeds, leaves, and rubbish of almost any kind would serve for the purpose, and I have often thought that if I could but spread the so-called manure heap under the cattle again, I could double its value.

Litter not used.

How manure might be better preserved.

Where the cattle are better cared for, earth-nut, gingelly cake, gram, and other foods having high manurial values are given to them frequently, but it is not borne in mind that with these more concentrated foods it is only about one-tenth of the nitrogenous and mineral constituents of the foods that actually goes on to the body of the animal and repairs its waste, but that nearly nine-tenths remain in the solid and liquid droppings, It is the knowledge of this fact which has made English farmers careful to preserve the manure of cake-fed cattle, and to keep their stock in covered yards instead of in the open.

Another frequent source of loss is, that the manure is often put, not in pits, but in loose heaps into which sun and rain can easily penetrate. Even when pits occur, they are often not much more than holes dug in the ground. If the bottom of the pit were well rammed down and the sides beaten firmly, or, where possible, plastered over with clay and allowed to harden, much loss would be saved. The manure, once in the pit, ought to be turned over occasionally, even in India, so as to get the drier portions mixed with the moister, and to make the mass rot evenly together. When the rains come, there is no difficulty in covering the pits with earth, and if the manure were well made, and less like the contents of a rubbish heap, less space would be taken up, and it would well repay to cover it with earth as suggested.

Drainings from manure heaps.

In Appendix F. I have given an analysis of a sample of the liquid which was draining away from a manure heap at Bartchinhulla, Munjerabad, Mysore, and alongside I have put the analysis of a similar sample from a manure heap in England, These figures show that the drainings from the Indian manure heap are slightly richer, both in solid matters (including potash and phosphoric acid), than those in the English sample, and that they contain considerably more nitrogen. It is evident, therefore, that allowing the drainings to go to waste is productive of considerable loss in India, equally as it has been found to be the case in England.

Objections to use of litter.

147. One objection made to littering cattle is, that if they were kept in sheds with litter under them they would be pestered with *ticks* and flies, and that on this account cattle have to be occasionally tethered out in the open fields. Of course, when flies or *ticks* are particularly troublesome, the cattle can be tethered outside, if necessary, just the same; but it is simply the general principle that I am advocating, one which, if adopted, would result, I am sure, in much saving.

Another objection is the one which the English farmer made when covered yards were first introduced, viz., that the cattle would be unhealthy; however, in England this has not been found to be the case, and, even as it now is, Indian cattle are often tied up in sheds; so I do not believe for a moment that the sprinkling of a small amount of litter, coarse grass, &c., supplemented by loose earth, would have any other effect than to make the sheds smell very much sweeter and cause a very important saving in manure. The popular idea in India, that cattle kept in sheds with litter put under them would fall ill, has been disproved by a 15 years' experience at the Saidapet Farm, Madras. Mr. Benson adds, from his own observations in the Presidency, that he has never heard of a case where any harm has resulted to the cattle from their being littered in sheds.

To my mind, a much more potent reason given for the non-adoption of the system is found in the answer which a *raiyat* gave me at Avenashi (Coimbatore). "It is hard enough to get "sheds for ourselves," he said; "how shall we get them for "our cattle?"

Instances of manure being badly kept.

148. It is clear to me from what I have seen all over the country, and also from the writings of others, that manure is not well kept, and that there is great room for improvement in this particular.

(*a*) Punjab.

A little beyond Multan I saw heaps of dung scattered over the fields; they had been left out in this way for over a month.

At Gújrat I noticed that upon the manure heaps was thrown a quantity of stalks and other material which would have done over and over again for litter. The greater part of the refuse is sold for the local trade of pottery-making, and the cultivators mainly depend for manure upon the coming of the silt from streams.

Mr. E. B. Francis, of Ferozepore, writes to me:—

" The most important question in the improvement of our agriculture is " to improve the collection and storage of manure, which would at the same " time be a measure of sanitation."

(*b*) North-West Provinces.

It is a frequent practice at Cawnpore to spread the manure out on the fields early, and to leave it in heaps until the rain comes. By doing this, considerable loss is incurred; the manure ought to be spread out at once over the ground, and then the loss would not occur.

Mr. Moens, in the Bareilly Settlement Report, says:—

" There are two points on which our agriculturists need instruction— " (1) growing green crops for cattle; (2) the proper management of their " manure."

(*c*) Bengal.

In Tirhoot, I saw near Bara, heaps of manure lying in fields where they had been exposed for several weeks, and were fast losing their goodness.

The following extracts are taken from Bengal Reports:—

Palamau.—" Manure is kept on the bare ground, and a great deal is " wasted."

Burdwan.—" Manure heaps are not well kept, and the urine is wasted. " Sometimes the heap is very carelessly managed, and let to get too dry. No " litter is used, and the urine is allowed to sink into the mud floor of the " cow-shed."

Dacca.—" Instances are not wanting of heaps of rich-fed cattle-manure " wasted."

(*d*) Madras.

In only a few places in Madras did I find any attention paid to the preservation of manure. At Avenashi no litter of any kind was used, and the cultivators seemed even to be unaware that leaves might be used as litter. On the manure heap a quantity of straw, weeds, &c. was thrown, but it was not rotted at all, and might quite well have been used as litter. All this time the bullocks were tethered in the open, and their urine was being wasted on the hard bare ground. If only the stalks, &c. had been thrown under the cattle the urine might have been partially soaked up. It is only right to add here, that the *raiyats* expressed themselves as very ready to receive instruction from anyone who would impart it to them.

At Shiyali and Madura I saw no litter used, except in one instance.

Mr. Benson writing of Kurnool, remarks on the bad way in which manure is kept.

Of Pallachi, in the Coimbatore district, Mr. Nicholson says:—

" The improvidence of the *raiyat* is here exhibited in his reckless waste " of manure, whether animal or otherwise, which lies everywhere around the " villages."

(*e*) Government Experimental Farms.

Even at the Government Experimental Farms, although in some cases care was taken to store the manure better than the *raiyats* did, I found there was still great room for improvement.

I must make an exception in the case of the Saidapet Farm, Madras, for, here, littering of cattle was carefully done. But at one of the Bombay Farms (Poona) the urine was allowed to trickle down an open drain, merely cut in the earth, but not piped in any way, and was supposed to flow on to a manure heap at the other side of the farm buildings, and situated a considerable distance off. The consequence was, that, so far as I could see, the urine was all absorbed in the earth before it reached the heap, except, perhaps, when a heavy fall of rain might wash it down in a diluted state. The solid dung was thrown on the heap along with stalks, &c., and the whole was left exposed to sun and rain. At the other Bombay farm (Bhadgaon) much more care had been taken, and better manure was produced, although the heap ought to have been better mixed up, and turned occasionally; the urine from the cattle was, however, allowed to mingle with the rain water from the roofs of the sheddings.

The value of leaves.

149. I believe that a great deal might be done by showing the usefulness of leaves for litter. When I was in Mysore I saw leaves being used by coffee planters as litter in covered sheds for the making of cattle-manure, and it is quite feasible to extend this practice to many other parts. A slight sprinkling of fresh leaves on the surface every now and then is all that is necessary, whilst the lower layers get trodden and matted well together, forming capital manure. In Table XI., paragraph 146, I have given two analyses of leaves collected for this purpose, a large quantity having been mixed carefully and subdivided repeatedly to get average samples. A comparison of these analyses with that of farmyard manure (Table VIII., paragraph 121), will show that there is more nitrogen and about the same amount of potash in the leaves as in the dung; the large proportion of vegetable (organic) matter must also exercise decided benefit. In one instance the amount of phosphate of lime is as much in the leaves as in the farmyard manure. The two analyses of leaves show considerable variation in the amount of mineral matter in each, this arising, doubtless, from different kinds of leaves being used. The relative values of different kinds of leaves for manurial purposes has still to be worked out. The leaves of the *Jack-fruit* tree (*Artocarpus integrifolia*) formed a large proportion of the sample marked H. The leaves analysed were those collected on Mr. R. H. Elliot's coffee estate in Mysore, and were similar to those he was in the habit of using for littering his bullocks. In some parts, for example, on the Malabar coast, it is the practice to collect and use leaves for manure.

Instances of manure being well preserved.

150. If I have spoken of manure being badly kept, it is only right to mention a few instances where it is better looked after:—

The Saidapet Farm at Madras has already been spoken of as one instance.

On the eastern side of Rawal Pindi it is the practice to impregnate stable litter with urine before throwing it on the manure heap.

In Tinnevelly, earth is often thrown over manure heaps before these are used for the cotton crop.

Littering of cattle by the coffee planters in Mysore has been referred to.

At Shiyali Mr. S. Sabanayagam Mudliar makes pits and clamps the manure closely together; in Gujarát (Bombay) manure is kept in pits and not in heaps; at Nadiad Mr. Becherdas Viharidas Desai has a very large masonry pit in which manure is stored, and from which his tenants (those from whom he takes a share of the produce) are supplied. It was at Nadiad, too, that I witnessed perhaps the most careful method of conservation of manure to be found anywhere in India At. the time of my visit, the method was unfortunately threatened with abolition through the action of the Sanitary Authority. The practice in the town was, to keep the cattle in sheds within the compounds; the ground sloped away into one corner close at hand, where a pit was carefully dug and plastered; a channel was cut, leading from where the cows stood, and along this the urine was led into the pit (a distance of only a few yards). In this way the urine was soaked up and absorbed by the solid excrements, ashes, and house-sweepings. As fresh manure was dropped it was added to the heap by plastering it over the surface. In this way an almost solid block of first-rate manure, including the urine, was formed, and the surface getting quickly hard and dry, there was little or no smell, nor anything objectionable.

Necessity of teaching the *raiyat* a better practice.

151. The instances of manure being properly preserved are, however, very rare, and, broadly speaking, it may be said that the Native does not know the best way of making cattle-manure, nor of preserving it when he has it. At the same time I fully believe that if he were shown how to do it, and were to be convinced that the practice is better than his present one, he would adopt it, and would litter his cattle.

The work of Government Experimental Farms.

A great opportunity is given to Government Experimental Farms to show how this can be done. If this matter were seriously taken up simultaneously at all Experimental Farms, and the cultivator were shown (as I am sure he would be) that better manure could be made, and better crops be grown as the result of saving the urine and storing the whole carefully, it would do far more good than experimenting with artificial manures which are altogether beyond the reach of the *raiyat.*

Village sanitation.

152. My enquiries into the subject of the better conservation of cattle-manure brought me into contact with points concerning village sanitation. To one of these, as distinctly affecting agriculture, I must refer, more especially as the extended application of the sanitary rules is contemplated. This I can best illustrate by the instance of Nadiad, in Gujarát (Bombay), to which I referred in paragraph 150. I there described the careful method by which the cultivators preserved the solid and liquid droppings of their cattle, keeping them, as well as the ashes, house-sweepings, &c., in such a way that there was the minimum of agricultural loss, and at the same time no smell or other objectionable feature was introduced.

Hardship of the sanitary rules illustrated in the case of Nadiad.

Notwithstanding the care exercised by the cultivators, the sanitary authorities, in their activity, had ordered the removal of the manure heaps, and had forbidden the keeping of pits within the precincts of the dwellings. The consequence of this was, that when I visited Nadiad in July 1890, instead of there being closely-packed heaps of well-rotted manure within the compounds, the urine being absorbed before it had had time to decompose, I found, lying along the roadsides, or in the lanes, or by the hedge-sides, numerous small loosely-packed unfermented heaps of fresh manure and rubbish, on which the rain beat down, washing out the goodness, and rendering it cold and unfermentable. Women might be seen carrying out in baskets on their heads mere handfuls of manure, they having frequently to go a considerable distance several times a day. Within the compounds it was even worse, for the cattle being still kept there, the urine, now no longer absorbed nor allowed to collect in the pit, flowed over the ground, and, mingling with the rain water, ran into the open street and along the sides of it, producing in its decomposition, wherever it dried up, a powerful smell which was the very reverse of sanitary. The effect of the so-called remedy was to produce a state of things infinitely worse than before. But it is the agricultural loss to which I wish particularly to refer. The people (they are *Patidars*) complained bitterly of having to convey the small lots of manure outside the town every day; they said that it was against the *Patidars'* feelings to let their women carry the manure out themselves, and so they had to pay for hired labourers to do it; that, when the heaps were put out, they were constantly liable to be stolen; that the manure was not well-made, the urine was lost, and the heap much spoilt by the rain, so that it never rotted properly. To test them, I asked to see what they called *well-made* manure, and soon I was shown some well-rotted, nearly black, rich manure, obtained, no doubt, from a manure pit which had not yet been removed. The quality of this was such as to convince me that these people, at least, knew what good manure was and how to make it. In a part like this, where a magnificent cultivation was in a very great measure the result of the careful conservation of manure, it seemed to me a great mistake that the sanitary authorities should have stepped in only to produce a state of things infinitely worse than before in a sanitary light, and one that involved decided agricultural loss. It is absurd to take such measures while still allowing cattle to remain within the compounds, the urine polluting the streets, and the manure heaps making the roadsides objectionable. Either the *Patidars* ought to be allowed to follow their economical and unobjectionable practice, or the cattle ought not to be allowed to stand at all within the compounds. The reason stated for the action of the authorities was, that human ordure was also put on the heaps in the pits, and a rule was made to compel the people to resort to the latrines outside the village. Even if a little ordure did so go, it was of small consequence and showed a sense of economy; and, besides, whatever sanitary rules may be made, I do not believe that they will ever succeed in compelling the women to go out at night into the fields where the latrines are. The people of Nadiad are very healthy, and epidemics are much more frequent in the towns than in these rural districts. It was pointed out also that, while the presence of the manure heaps was considered by the sanitary authorities to be highly dangerous, it was the practice everywhere to plaster the walls and floors of houses with cow-dung, and yet no one got ill from it. Fully one-third of the entire population of Nadiad were cultivators.*

When I was in the Central Provinces I found that similar rules were being enforced on account of the fear of cholera. Nevertheless, the cattle were still allowed to be tied up at the houses, although the manure had to be carried outside the villages. Here, however, the manure heaps were not kept with the same care as was exercised at Nadiad.

Closing over of drinking wells.

I might mention in this connection the desirability of covering over, both in towns and in villages, all wells which are used solely for drinking purposes.

In view of the contemplated extension of the application of sanitary rules, I have gone into these matters at considerable length, as I think that attention should be paid to them.

Wider distribution of dwellings and wells over the land advisable.

153. There is one way in which the manure supply, both of cattle-manure and of night-soil, could be used to better advantage, but it is hardly a feasible plan now, I fear. I have remarked upon the appearance of a North-West village, the habitations crowded together, the wells and the best cultivation and the most highly manured land lying close around the village site. This, doubtless, has arisen out of the experience of the past, owing to the necessity of combination for self-protection against the raids of marauders. Undoubtedly, however, if the habitations could now be more scattered over the land, and not be huddled together on one spot, the manure would be more widely distributed also, and probably not be so much wasted; the wells also would be dotted about and not clustered together. Captain Chapman told me that when he came into possession of his property at Shahpore, in Oudh, one of the first things he did was to dig wells, not around the village site, but distributed over different parts of the estate. The consequence was, that when new settlers came, they fixed their dwellings where the wells were, and thus the manure from their cattle was distributed over a wider area and was not concentrated around the dwellings, leaving the outlying parts unmanured.

Could the habitations be more scattered, and the wells too, the land would certainly be better manured.

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* Since writing the above, I have heard that the Collector of Nadiad has recommended that the inhabitants be allowed to keep their manure heaps in the town as before, provided that each man makes a pit with brick sides, and that the manure be removed to the fields as soon as the pit is full.

CONCLUSIONS.

CONCLUSIONS.

154. Whilst a few soils, such as those of silt-renewed tracts, the black cotton-soil, and newly-reclaimed or virgin land, may not require manure, it may be said of the greater part of India that the necessity for using manure is enormous, and the supply of it is notoriously inadequate. Water and manure are interdependent, and, just as the former has been and is still being provided for, so must attention be given to the supply of manure. These two factors, water and manure, constitute the *raiyat's* great needs, and in their supply consists, very largely, the Improvement of Indian agriculture. It has been shown in this chapter that, under existing circumstances, the manurial supplies in use are not sufficient to replace the crops that are taken off the land; further, that the increasing tendency to export both crops and manures must cause a deterioration of the soil.

In considering the various sources of manure, it has been pointed out that, with the exception of cattle-manure, the amount and use of them is most limited.

Practically, therefore, everything centres in cattle-manure, and the question of how to use it to better advantage.

There are two main causes which prevent manure from being properly utilised. The first is, that it is burnt as fuel because there is a deficient supply of wood; the second is, that it is not properly made, inasmuch as the urine is altogether wasted, and the manure is badly kept. The second of these two causes may be gradually removed by the spread of agricultural instruction, and by the example of Government Farms and Estates. The first cause, however, is one that cannot be removed except by the taking of bold measures by Government, such as those taken in introducing canals and in carrying them throughout the country. Government cannot directly provide manure for the land, but what they can do is, to provide wood to take the place of cow-dung as fuel, and so to liberate the latter for its proper use upon the land. In short, Government must now turn to supplying wood for agricultural purposes, just as they have supplied and are supplying water.

The situation has been sketched out in Chapter V. (paragraph 51), when dealing with the question of exhaustion of soil. A rapidly-increasing population creates a greater demand upon the soil and upon the food crops which it bears. Could the produce be increased even by one or two bushels per acre, as Sir James Caird estimates, the difficulty of population would be met, but without more manure the soil cannot do it, and the export both of crops and manures is *removing* instead of *adding to* its fertility. Meantime the increase of water facilities, through Government aid, calls for the use of more manure, but the latter is for the greater part wasted because the supply of wood for use as fuel is inadequate. What is the position of Government in the matter? For practical purposes Government are in the place of a landlord, and as such it is their duty to look after their property, and to see that it is kept up, and not be allowed to become impoverished The present system is one of gradual soil-exhaustion, which must end in a decline, slow it may be, but still a decline of fertility and of productive power. It behoves Government, therefore, for their own sake, to take this matter into serious consideration, and, while there is yet time, to push forward active steps for preventing the decline in the value of their property. Unless this situation be faced, Government must be distinctly prepared to see the land bring in a diminished revenue, and to find the people less able to live upon the land. Nor must the bearing upon the question of Famine be ignored.

Mr. Nicholson has pointed out that in times of serious drought manured land is able to yield at least something, or even a moderate crop, whilst unmanured land may produce absolutely nothing. The existence of some crop, instead of total failure, may make all the difference between famine and no famine.

Lastly, there is the consideration that if more manure be supplied, the land will become more fertile, and be capable of returning an increased revenue to the State. It therefore becomes, I maintain, the duty of Government, both to themselves and to the people, to supply manure to the land. In this, now, must rest practically the Improvement of Agriculture. Of what benefit will it be to cover the country with Agricultural Schools, and to teach better methods, unless the one great want of the cultivator be met, viz., more Manure? Of what use will it be to demonstrate at Experimental Farms the value of manure, and how to preserve it, when the cultivator has to burn it because he has nothing else for fuel?

The one way in which alone this question of paramount importance can be met is by supplying more *Wood*, and thus setting free the manure for use on the land. I shall deal in the next chapter with the exact way in which wood might be supplied, but I may say here that it is in this connection mainly that I advocate the establishment of "Fuel and Fodder Reserves."

To adopt the method followed in my earlier chapters, of summarising possible improvements in agriculture—it has been seen that considerable differences exist in agricultural practice according as the facilities for manure supply are greater or less. Improvement in agriculture will take place through the modification of these differences. This cannot be effected directly by the people to any great extent, although, here and there, as with the *Káchhi* cultivation, example will tell. Government will be able to assist in the work by the spread of Agricultural Education. Education will have a powerful influence in breaking down prejudice, and, by it, the better practices and their advantages will be made known.

But the work of Government does not stop here; *positive* measures, too, must be taken. First and foremost, Government must supply wood for agricultural purposes, to take the place of the cow-dung at present burnt. Then, Agricultural Departments must, by means of an organised system of *agricultural enquiry*, ascertain the manurial facilities and needs of each part of the country; they must acquaint themselves with the practice of the best parts, and transfer it, when possible, to others; they must ascertain and demonstrate at Experimental Farms the value of various manures, and, in especial, the benefit of littering cattle, and the better preservation of manure. It is evident that in this work advantage will have to be taken, not only of a knowledge of indigenous practice, but also of Western science and experience. In this connection I would urge, as most desirable, the appointment of an Agricultural Chemist, who may render much assistance in utilising existing manurial sources, in demonstrating their use and value, in possibly discovering new manurial resources, and in solving various questions bearing on the relation of soils, crops, and manures.

RECOMMENDATIONS.

RECOMMENDATIONS.

155. I advocate,—

The establishment of "Fuel and Fodder Reserves," for the primary purpose of supplying wood to take the place of cow-dung as fuel.

The inauguration of a system of Agricultural Enquiry, to ascertain the manurial facilities and requirements of each part of the country.

The spread of Agricultural Education, to assist in teaching the value of better practices, and to break down prejudice.

The employment of Experimental Farms, for the purpose of showing how manurial resources can be best used and conserved, and for demonstrating the value of, and extending, the better practices of other parts.

The employment of an Agricultural Chemist, to assist in utilising existing manurial resources to best purpose, in discovering fresh ones, and in the solution of agricultural problems.

CHAPTER VIII.

CHAPTER VIII.

WOOD.

WOOD.

156. FROM the last chapter, in which the manurial resources of India were considered, I pass now to discuss the wood supply of the country, and how it may be increased, primarily with the view of setting free more manure for the land by the substitution of wood for cow-dung as fuel.

In order to understand how agricultural ends in the matter of wood supply are to be best served, it is necessary to briefly review the policy which, in the early days of the Forest Department, was adopted in regard to forests and other supplies of wood, and also the changes which have been called for in more recent times.

Early policy of Forest Administration.

157. At the time of its creation, about 1866, the Forest Department found the forests of the country fast disappearing before the spread of cultivation, and before the reckless destruction carried on by the people. Agricultural resources were vanishing, and the climate was, not improbably, being affected injuriously. None too soon did the Forest Department step in to prevent the entire deforestation of the country, which would most certainly have taken place. As the demand for cultivation spread, so would the forests have disappeared before the plough, had not a strong hand been interposed to save what was still remaining.

The people, left to themselves, have never been able to manage forests properly, nor to understand how forests may be conserved and utilised to the best advantage. Their practice had been simply to cut and clear the forest to make room for cultivation, and, as soon as the virgin soil was spent, they pushed on, broke up fresh land and cleared more forest. And this, if allowed, they would still do, thinking only of the immediate present, and not of the future.

Good work done by Forest Department.

But the Forest Department, by its intervention, has stopped in a great measure the work of destruction, and has not only brought in a large, and ensured a continuous, revenue to Government, but it has laid the foundations of a system which, if properly directed, may be made to conduce greatly to the agricultural prosperity of India. But when it began its work its chief duties were the preservation and development of large timber forests, such as the teak forests of Lower Burma, the *sâl* forests of Oudh, and the *deodar* forests of the Himalayas, or the forests of the Western Ghâts. Its objects were in no sense agricultural, and its success was gauged mainly by fiscal considerations; the Department was to be a revenue-paying one. Indeed, we may go so far as to say that its interests were *opposed* to agriculture, and its intent was rather to *exclude* agriculture than to admit it to articipation

Its success measured by direct financial returns.

in the benefits. The chief reason for this was, that the admission of grazing into the forests would have destroyed the young seedlings, and have rendered the maintenance of the forests by natural reproduction impossible. So far as the original design went, the Forest Department deserves full recognition of the admirable work which it has done in saving to the country the forests now under its care, but which, if left to the people, would have been ruthlessly destroyed.

Causes of a change of policy.

158. At that time, however, these large timber forests were not in contact with important tracts of cultivation, but were, for the most part, situated on hills and mountain ranges, only occasionally bordering on cultivation, and that of a sparse and backward kind, often carried on by half-wild tribes. As the population increased, and the pressure on the land called for extension of the cultivated area, so the latter spread to the borders of the forests. Again, of recent years, there has been a feeling that the forests and other wooded tracts ought to be made to serve the interests of agriculture more directly than they have done in the past, and that areas should be reserved and fresh ones be created in the midst of the cultivated land, and not merely on hills and mountain ranges. The Governments of India, Bombay, and Madras have been urging their respective Forest Departments in this direction, and have endeavoured to extend the influence of the forests from the remoter hills to the cultivated plains. In this way the policy of the Forest Department has been undergoing a change, in order to meet the altered conditions of agriculture. The old traditions which animated its officers, viz., that the sole aims of a forester were to grow big timber and to show a large revenue, are wearing off, and, whereas considerable prejudice existed in the past against the Department, by reason of its being opposed to agriculture, a feeling is now growing, among the more enlightened of its officers at least, that one great object should be to directly *serve* agricultural interests. It is this altered policy that I wish to support, and to show, if possible, the need of giving fuller scope to the usefulness of the Department.

Agricultural requirements in respect of wood.

159. The requirements of the agriculturist in respect of wood are, small timber for house-building, wood for making implements, and firewood; the last-named principally to take the place of the cow-dung which, though the most valuable manure at the *raiyat's* disposal, is, nevertheless, generally burnt as fuel in default of wood.

The paramount importance of supplying wood to replace dung as fuel.

160. In the last chapter, after reviewing the various sources of manure supply, we saw that they were very limited in number, and that the only material available in any quantity was the ordinary cattle-dung. Further, we found that, wherever wood was sufficiently abundant, dung was used for the land and it was not burnt; but that where wood was deficient, manure was burnt in the absence of any other source of fuel, and that the land was thus deprived of it. The dependence of the soil for its fertility upon the supply of water and of manure was also instanced. The conclusion was, accordingly, drawn that the supply of wood to serve as fuel forms one of the most important factors in maintaining the fertility of the soil, or, in other words, the prosperity of agriculture. I can hardly put this too strongly, for it is *the one* practical measure on which I place the most importance; it is that which calls for the most urgent attention, and from which the greatest benefits may be expected to follow. I make, in my Report, other recommendations and suggestions, it is true, but I consider them *minor* ones compared with this. Let us once more review the position. A country exporting manures as well as crops, not utilising even the night-soil, and then burning the cattle-dung because fuel is scarce; an ever-increasing population, and a greater demand on the land to supply more and larger crops, these latter depending on more manure being available. What more ready plan than to supply wood as fuel in order to save the manure for the land? In the substitution of wood for cow-dung no question of *caste* prejudice is involved, such as is the case in the use of bones or of night-soil. It is a measure which the people would adopt, and have adopted, on their own account, wherever it has been possible. Further, the improvement thus to be effected is one which proceeds upon the right lines, viz., the improvement of Indian Agriculture from *within* rather than from *without.*

The importance of this to Government.

I therefore do not hesitate to say that, just as Government foresaw the difficulties of the people in supplying themselves with water, and so provided it for them, so must attention be now turned to the difficulties of the people in the matter of fuel, and, seeing how impossible it is for them to provide it for themselves, Government must do this for them too. It is not in the interests of the people alone that I would urge this, for, having fully discussed all other ways of increasing the manure supply, it is clear that this is *the one way* in which it can be effected, and, if not effected, sooner or later the land must fall off in productive power, and the revenue derived therefrom by the State must decline too. Accordingly, I regard the provision of fuel as the most potent means of maintaining prosperity, not alone to the cultivators, but to the State itself, and as a measure which the latter, *in its own interests,* should take up immediately. If wood could be made to take the place of dung for fuel we should soon come to realise that more wood means more manure, that more manure means more crops, and more crops an increasing revenue to the State; whilst, to the cultivator, it implies more fodder, better cattle, and more manure again to ensure the future fertility of the soil.

Previous expressions of this view.

161. I do not take to myself credit for more than emphasising what others have already pointed out on this subject. As much as 17 years ago Mr. R. H. Elliot, writing in the "Times," urged the necessity of "Fuel Reserves" for India, and much that he then said has since proved to be true. The same views have been urged by others, but there is call now for more definite action than there has been in the past. What has been done so far, whilst not without benefit to agriculture, has, to my mind, taken mainly the form of supplying wood for the requirements of large towns and railways. Although agriculture has been indirectly helped by the smaller amount of dung burnt in consequence, yet I think that hardly enough importance has been attached to the bearing of the wood supply upon the fertility of the soil, and to the need of supplying firewood to villages as well as to towns.

Other advantages of tree-growing.

Influence on climate.

162. The influence of an extended growth of wood upon the climate has been fully dealt with in paragraph 38 of Chapter IV., and has been referred to as affording a possible, though perhaps only local, amelioration of the severities of climate.

Protection from winds and sun.

There is another feature about tree-growing which must not be forgotten, viz., the shelter and protection afforded from the burning sun, and also from the violent winds. Mr. Nicholson points out that many tracts in the Coimbatore district are exposed to severe winds. He says:—

> *Dharapuram District.*—" Hedges and belts of trees would be peculiarly " useful in this wind-swept tract."
>
> *Udamalpet.*—" It is the most open *taluk* in the district, having few hedges " and very few trees; hence the winds of the south-west monsoon are " severely felt."

Many parts of Mysore suffer greatly from damage by wind. On the North-West frontier the presence of trees is indispensable to the growing of grass.

Supply of leaves.

Famine food.

The advantages of tree-growing in connection with the supply of leaves for litter and for manure have been spoken of in Chapter VII. (*see* paragraph 149), and to this may be added the provision of food afforded both to men and cattle in time of famine, if suitable kinds of trees be grown.

What Governmens have already done in this direction.

163. Whilst laying particular stress, as I have done, on the need for an extended wood supply, and mainly for the purpose of providing fuel, it would be wrong to ignore what the respective Governments of India, Bombay, and Madras have done, or, at least, have urged on their Forest Departments the necessity for doing. Without going into particulars, I would indicate the general lines that have been taken.

Sir D. Brandis' work.

It was Dr. (subsequently Sir Dietrich) Brandis, the real founder of the existing Imperial Forest Department, who gave the great impulse to the growth of what may be termed "Agricultural Forests." It was he who clearly saw the line which the Forest policy of the future would have to take, and who did his best to guide it in this direction. Already in 1873, at his suggestion, tracts had been taken up in Ajmere-

Merwara, a little territory under direct Imperial control, and thus available for the purpose. This will be explained more in detail later, but it may be said here that the results were very satisfactory, and Sir D. Brandis wrote :—

> "It may be pointed out that in all except the most arid tracts, or where "denudation is complete and of long standing, mere protection, aided by "sowing and planting in suitable places, will gradually clothe grounds with "trees and shrubs."

Sir D. Brandis, at the close of his Indian career, went himself to Madras to assist the Madras Government in framing their policy of "Agricultural Forests," and largely to his efforts it is due that in Madras so much has been done to make the Forest Department serve agricultural interests.

Recommendations of Famine Commission.

The Famine Commissioners showed that they were alive to the way in which the forests might assist agriculture. They said in their Report :—

> "So far as any immediate advantage is to be sought from "the extension of forest in respect to protection against "drought it will, in our opinion, be mainly in the direction "of the judicious enclosure and protection of tracts . . . . "from which improved and more certain pasture may be "secured for the cattle of the vicinity; a supply of fire-"wood secured which may lead to a more general utilisation "of animal manure for agriculture, and a possible addition "made to the power of the subsoil to retain its moisture, and "to the prospect of maintaining the supply of water in the "wells."

Government of India's Resolution of March 1883.

The Government of India, in following up the recommendations of the Famine Commission, issued, in March 1883, a Resolution calling attention to the growing decrease in the area of grazing land and wooded tracts in many parts, notably the Punjab, the North-West Provinces, and the Central Provinces, and to the damage done through excessive grazing. They quoted numerous cases, such as Banda, where, in the famine of 1878–79, grazing areas had been instrumental in saving thousands of cattle; and other instances, such as Jhansi and Rohtak, in which thousands had perished for lack of these areas. They asked, therefore, the attention of Provincial Agricultural Departments to this question, and the co-operation of the Forest Department. It was suggested that enquiry should be made by district officers, with a view of ascertaining how far cattle needed protection, and what lands, either Government property or else purchasable at reasonable rates, were available for the formation of what were thenceforth to be termed "Fuel and Fodder Reserves."

It was recommended that the purchase of land should be effected, provided the price came within a limit of Rs. 20,000 for 10 square miles. The actual management of the "Reserves" was intended to be in the hands of the Forest Department.

Enquiries were next made, at Government suggestion, as to whether suitable spots for "Fuel and Fodder Reserves" existed along canal banks and lines of railway.

Action taken in North-West Provinces and Punjab.

As the result of the enquiries made, it was ascertained that in the Doab (North-West Provinces) saline land (*usar*) could be obtained in abundance, and also a certain amount of *ravine* land, both of which would pay for growing trees and grass upon. Ravine lands at Etawah and at Jhansi were subsequently taken up, and canal plantations have been established at Cawnpore, Agra, Rurki, Delhi, and other parts of the North-West Provinces and the Punjab. Other plantations, such as those of Changa Manga, and Shahdara, near Lahore, had been previously created by the Forest Department.

Mention was made just now also of the "reserves" established at Ajmere-Merwara at the instigation of Sir D. Brandis.

Action in Madras.

But it is in Madras that more has been done than anywhere else to assist agriculture by means of the forests. One great reason for this is, that in this Presidency the waste land is the property of Government, and they can therefore dispose of it as they like. This is also the case in Bombay, and wherever no permanent settlement of the land exists. The exceptional circumstance that Ajmere-Merwara was under the direct control of the Government of India enabled land similarly to be taken up there for the purpose of forming "reserves." Again, in Madras, cultivated land is more or less mixed up with undulating wood-producing country, and thus field and forest come in close proximity, presenting a great contrast to the vast level plain which includes the Punjab, North-West Provinces, and Bengal.

The large *timber-producing* forests.

164. I propose now to deal in succession with the different ways in which at present the supply of wood is maintained, and then to consider in what directions extension for agricultural ends is most needed.

First of all come the large *timber-producing forests.* Everyone must recognise the necessity of having these; they supply Europe with teak, for example, and are requisite for all building purposes, and for providing railway sleepers, furniture, &c. As we have seen, they are for the most part still removed from the general area of cultivation, and it is mostly on the hills and mountain ranges that they are found. They are clearly demarcated and defined as being forests for the primary purpose of supplying *large timber,* and should, I think, be rightly treated as such.

In them the main end should be kept in view, and every means be used to grow as fine and as large timber as may be required. From these forests grazing must be excluded entirely, if the forest be worked on the *jardinage* system (that according to which trees of all ages, from seedlings to mature trees, are mixed up together, singly or in groups, everywhere over the whole area, the fellings being similarly located at short intervals wherever a suitable tree may happen to be). The object being to encourage natural reproduction and restocking, grazing would do great damage, inasmuch as the seedlings would speedily be nibbled off or trampled down. If the forest be worked in blocks, trees of like age being classed into separate groups, it would perhaps be possible, without direct damage to the forest, to admit grazing into particular blocks at certain times. In any case, in time of drought these forests would be the means of keeping alive many of the cattle of the country. But, beyond this exceptional event, in forests of this class I should like the forest officer to have full liberty and every facility for growing large timber independently of any minor considerations; also, I think that he should be allowed to strictly enforce rules for preventing forest fires and for excluding grazing, &c., as well as all others that are necessary to the attainment of his main purpose.

Impossibility of having Timber Forests and Agriculture on the same area.

It is, in short, impossible to have timber forests and agriculture on the same area; the most that these forests can do for agriculture is, to provide, for the immediate vicinity, a certain amount of small wood and firewood obtained from the timber that is felled, and to serve as a refuge for cattle in time of drought and famine.

Of this nature are the Coorg forests, which I visited under the guidance of Mr. H. C. Hill, Officiating Inspector General of Forests. They are at a distance from, and not in the midst of or near, cultivation, and they could not now be brought to benefit directly the actual cultivators of populated villages at a distance. Around them is only a scattered agriculture and a meagre population. Here, I should say, are forests which by their position are best adapted for *timber-growing* purposes, and for such purposes they should be kept. They are too far off to supply the cultivator with firewood at a rate which he could afford to pay, and which would at the same time be remunerative to the Forest Department; whilst, to the cultivator, even were there any considerable agricultural population, the cost of carting would be prohibitive. It may, however, pay quite well to remove large logs, such as contractors or railway companies would buy. I am obliged, therefore, to look on these forests as likely to do but little to increase the supply of manure available for the land through the substitution of wood for cow-dung as fuel.

Whilst advocating the closer attention of the Forest Department to agricultural ends, and commending the step taken in 1884, which brought the Department under the Imperial Department of Agriculture, I have no wish to urge interference with the necessary and legitimate purposes which the large timber-growing forests serve for the good of the country. Large timber is, and always will be, required, and to make the supply a means of obtaining a large revenue is a very proper end, where, as I have shown, other interests do not

Necessity of maintaining Forest rules as to grazing and fires.

suffer thereby. I am, accordingly, in full sympathy with the Forest Department in their contention that, where the object is to grow timber, it is necessary to close these forests altogether to grazing, or at least only to open certain blocks at a time, and to enforce stringently the rules which exist in regard to the prevention of forest fires. I have myself seen, over and over again, during my tour through the Coorg forests, instances of the damage done by forest fires; how that seedlings are killed and the entire natural reproduction, so essential in a timber forest, is completely stopped. I can quite understand, too, the damage that will be done in a forest where reproduction is going on, either on account of cattle trampling down the seedlings, or by goats pulling down the branches and young trees bodily, or by goats and sheep nibbling off the young shoots. Goats, in particular, must have no place in a forest of this kind.

Much has been said by certain writers in favour of the annual setting on fire of the forest grass, in order to get a fresh growth of herbage. The occasional clearing of the coarse dried grass by fire may result in the growth of a temporary crop of fresh grass to feed cattle for a month or so, but it simply means ruination to the forest, and the infliction of damage from which the forest will not for many a year recover. I have, therefore, no sympathy whatever with those who have maintained that it is a good thing to have an annual burning of the forest grass, or that the forests ought to be thrown open to unrestricted grazing. But I wish to make it clear that I am here speaking of forests which are essentially, by situation and natural conditions, *timber-producing* forests.

Classification of Forests.

165. The Forest Department recognises three classes of forests, (1) "Reserved Forests," or those which, being the property of Government, or over which they have proprietary rights, have been set aside and constituted "Reserved Forests;" (2) "Protected Forests," or those which, though the property of Government, or over which Government have proprietary rights, have not been included in a "reserved forest;" in these Government may declare any class of tree reserved, or close any part for a term not exceeding 20 years; (3) all other forest lands are termed "Unclassed Forests."

"Protected Forests."

166. Of "Protected Forests" I need say little more than that I think it would have been very much better to have made them all "Reserved Forests." The retaining of certain rights by Government, and allowing the people to do otherwise as they like, is not conducive to the forest serving the best purposes.

In many cases, notably the Punjab, the creation of "protected" forests has arisen, I believe, mainly from the fact that the Local Government have not had the courage to extend full protection to land which ought really to have been "reserved" forest. A partial protection only has been extended to them, the Local Government fearing to cause friction with the people. In view of the important issues of forest preservation, the reckless use of the forests by the people when uncontrolled, and the general unsatisfactoriness of the working of "protected" forests, it would, I think, have been much better to have taken the bold step at the outset. In the case of any land that is reserved, exclusion from it may be necessary for a time at first, but before long the benefit of doing this will be apparent, and even in the first year a quantity of grass will probably be available for cutting as fodder.

"Reserved Forests" near cultivation.

The advantages not fully realised by the people.

167. Among "Reserved Forests" are included the timber-growing forests which I have referred to in paragraph 164. I now intend to deal with those "reserved forests" which are near the cultivated areas, and which can be made to serve agricultural ends. The action taken by the respective Governments of India, Bombay, and Madras in extending the influence of the forests from the hills to the cultivated plains was, undoubtedly, a good one. But, from one cause and another, it has come about that, with some exceptions, the advantages of "reserved forests" have hardly been brought home to the agricultural population, and too often the latter have been inclined to regard the reservation of a forest as their *exclusion* from it, rather than as the means of providing a benefit for them.

The reasons for this.

The traditions of the Forest Department.

It is necessary to look briefly at the causes which have brought this about. Undoubtedly in the past there has been a tendency on the part of the Forest Department to grow large timber only, and to reap a large revenue by doing this. We have seen, in paragraph 157, how this naturally came about, and that it was the result of the duties with which the Department was charged at the outset. But the traditions have not altogether passed away even now, and there is still need of reminding the Department, as Sir D. Brandis did in 1883, that the growing of big timber is not the only, and often, indeed, may not be the main, object of a forester's existence.

Sir D. Brandis wrote in 1883 :—

> "It must now be distinctly recognised that not only does the provision "of timber and firewood come within the legitimate scope of forest administration in India, but one of its most important duties will, in future, be "to increase the supply of cattle fodder, particularly during seasons of "drought in the drier districts."

Difficulties in procuring land.

There have been, undoubtedly, considerable difficulties in the way of the Forest Department, and where, as in the case of Ajmere-Merwara, there has been no hindrance to procuring land, the Department has shown its readiness to minister to the more agricultural needs as well as to the growing of timber.

Nevertheless there is, I think, a great deal more that can be done, and what is chiefly needed is, to extend the action taken by the Madras Government.

I should, in justice, say here that among the officers of the Forest Department there are many who recognise the importance of the objects to which Sir D. Brandis refers, and who carry them out as far as they can. Some such men I met during my tours.

Difficulties in the way of extended action in an agricultural direction.

The financial check.

168. What prevents extended action is not any check from the Government of India, nor yet from the Forest Department, but it is a financial check, and one which accordingly prevents Local Governments from taking action. The Forest Department is practically called upon to show a large revenue, and is naturally proud of the profit it makes. At the same time it is a notoriously undermanned Department, but is unable to increase its staff materially (as would be necessary were the more agricultural purposes closely followed), unless by showing a still larger surplus to meet the expense of additional officers. So it has come about that, in the majority of cases, the officers have turned their efforts mainly to producing large timber wherever they could, even though the circumstances of the "reserved forests" would, in the wider sense of the good of the country as a whole, have often adapted them better to other purposes than timber-growing.

"Reserved Forests" often better adapted to other purposes than timber-growing.

169. It is by no means the case that timber-growing will always be the purpose to which the forest is best suited naturally, or the most desirable one when all considerations are taken into account. Areas have been taken up in the past, and the attempt has been made to grow on them timber for sale, whereas these areas were never fitted for such a purpose, but only for growing scrub-jungle and for providing grazing. There are many such instances in the Madras Presidency. If the Forest Department is told to conserve timber it will do it, and wherever it sees a chance. What must come to be understood is, that forests may be so situated or naturally so adapted that timber-growing may not always be the main end to be sought, but that what the forester is accustomed to regard as "accessories," such as, small timber, firewood, grass, &c., should, in many cases, be the main consideration, and that for which the forest should be worked. In some of the Bombay forests, for example, the supply of twigs and leaves for the *ráb* system of making seed-beds (*see* Chapter VII., paragraph 131), may be the most useful aid to agriculture, and the growing of trees that may be pollarded would do much more good than supplying timber. At Máhim (Bombay) and Hospet (Madras) I saw cultivators lopping the trees around their own fields, the twigs and leaves being utilised either for *ráb* or else directly as manure for rice fields. Nor were the trees ruthlessly destroyed, for they were only lopped once in four years. Similarly, some trees are most usefully grown for pollarding, the shoots being used as props for plantains or *betel* vine. At Máhim I counted over 50 new shoots on a pollarded *bhendi (Hibiscus)* tree, and I was told that the number went sometimes up to 100. The shoots take three years to grow to a sufficient size, and the trees live for 40 years. I could not help thinking it was much better for

Ráb.

Pollarding and lopping of trees.

the trees to thus yield a triennial supply of shoots for 40 years, than that they should be left alone all the time in order to afford at the close of it one single log of timber.

Where such is the case, and seeing that in wet regions the *ráb* system has been proved to be the best for rice cultivation, it would frequently be very legitimate for the Forest Department to work for the supply of *ráb* instead of for timber. The Forest Department have, in some instances, tried to undertake the provision of *ráb*, but the difficulty has been that they feel compelled to cut it according to rule, and then to stack and keep it, whereas the cultivators must have it fresh, and just when they want it, as well as at a not expensive rate.

The provision for existing rights.

170. In demarcating a "reserved forest" it is the practice to ascertain, register, and provide for the continuance of rights which are found to be already existing over such areas. But more than this is required. It is not enough to satisfy existing rights, or to provide for the wants of the people *immediately* around the reserved area, and then to say, "Having done this, we will now grow our timber." What I maintain is, that, having marked off the most suitable and more distant areas for timber-growing, the "reserved forests" which are nearer cultivation should be worked more in the interests of the people than has been the case in the past, and that the *first* consideration, and not the *last*, should be how the wants of the agricultural community generally (who are not fortunate enough to have acquired any rights) can be best met, and how the benefits which the forest reservation confers may be extended to as wide an area as possible. To this there are limits of distance beyond which firewood, &c. cannot be profitably carted, but my contention is, that the object to be kept in view should be to see *how large a number* of the cultivating villages *can* be provided for, not *how few must* have their actual rights supplied. When this is done, I have not a word to say against the remainder of the forest being utilised for timber-growing, for sale of fuel to towns, for letting out to graziers, &c., whichever be possible and most remunerative; but these must come *after*, and not *before*, the agricultural needs of the country.

Exception in favour of Ajmere-Merwara.

171. It is right that I should here make an exception in favour of what has been done in Ajmere-Merwara. The reserves here, which I had the pleasure of visiting under Mr. H. C. Hill's guidance, quite meet the ends which they should fulfil. No attempt is made to grow large timber (the soil, indeed, is quite unsuited to it); but large quantities of small wood and of firewood are produced, and a considerable amount of grass is cut for fodder, whilst, even during my visit, the reserves had, in a time of drought, been the means of saving a number of cattle belonging to the surrounding villages.

I am told that similar reserves may be found in different districts of the Punjab.

If the example of Ajmere-Merwara were to be followed extensively, much good would certainly result, but, as it is, there is room for improvement, and my remarks made above hold good, I believe, in general.

System of annual licenses in "reserved forests."

172. As to firewood, it is quite true, as forest officers have pointed out to me, that the price of firewood must be regulated by the demand, and that firewood cannot be sold at one rate to a town and at another to the cultivator, or else the latter will at once resell his purchase at a profit. But, what I think might well be adopted is the system by which the inhabitants of certain defined areas around a "reserved forest" might be allowed, on payment of a certain yearly sum, to take out an annual license to remove what wood they require for building, implements, and firewood, as also fodder, &c., provided these be for their domestic use only, and not for sale; also to graze (when grazing can be provided) all cattle of which they are the *bonâ fide* owners. This would get rid of any difficulty as regards the price of firewood; and, inasmuch as the licenses would specify the particular blocks where the permission could be exercised, and would be liable to be cancelled if the restrictions were exceeded, the control would lie with the forest officer, who would determine the areas to be thus set off.

The only difficulty would be in the case of those who hold rights of grazing, of removing firewood, &c., and who would hardly be willing to pay an annual sum when before they had been free. This would, however, not apply everywhere, and where it did, the rights would have to be defined, just as is done at present in the case of "reserved forests."

The Forest Department undermanned.

173. I have spoken of the need of a larger staff of better-trained men in the Forest Department to carry out the working of forests in an agricultural direction. As the forests come more in contact with agriculture, so will there be need of greater supervision and more official protection against fire and against unauthorised grazing, &c. To take an example, in the Coorg forests there is only one European professional officer over an area consisting of 248 square miles of "reserved" forests, and 601 square miles of "protected" forests.

The Forest Department sometimes tries, or is expected, to perform impossibilities.

174. But the Forest Department is sometimes called upon, or else attempts, to perform impossibilities. When the need for serving agricultural ends has been impressed upon them, the officers have frequently been expected to produce out of the same forest large, medium-sized, and small timber, firewood, leaves, *râb* material, and grazing, all at once. In Bombay the Forest Department has decided that these varied wants can best be met by a 40 years' rotation. This means that *râb*, for example, could in any one year be only taken off one-fortieth of the area, a very insufficient amount in many cases. It is quite clear that cutting for *râb* must be done near cultivation, and that there must be regular working plans drawn up for it, the people being allowed to cut the material themselves over allotted areas, worked, say, on a three or four years' rotation, and payment to be by levy on the rice area cultivated, or on a village as a whole.

Again, the agriculturists being under the Revenue officials, there are not wanting instances where, owing to the absence of a proper understanding between these officials and those of the Forest Department, friction has been caused upon the closing of the forests, or by the issue of orders to stop the lopping of trees for *râb*.

Summary of difficulties of Forest Department, and its future policy.

175. Thus, partly from the nature of its action, of necessity a restricting one, but mainly from the obligations put upon it by the Executive Government, also from the impossibilities it has been asked to perform, and, lastly, from being greatly undermanned, the Forest Department has not been as popular in the past as it might have been. But I am sure that when it is fully recognised that there are other ends which the Forest Department should serve besides that of growing timber and making a large revenue out of the forests, the Department will readily carry these out to its best ability.

Such an end is that which I have indicated, the provision, for the agricultural community *primarily*, of facilities for obtaining what they require, viz., small timber, wood for implements, firewood, leaves, grass, or, where possible, grazing. No action would, I am sure, do more to render the Forest Department popular and its work one of widespreading benefit, could it be instructed to carry out such objects as the above, and to bring these facilities to the cultivators' doors. Such a policy would be one of *giving*, and not what the people have considered the past policy, one of *taking away*. The cultivators would then feel that the forests were a real benefit to them, and possibly much unculturable land would become clothed with trees and grass.

I cannot better conclude the consideration of this portion of my Report than by giving the following extract from a Resolution of the Madras Government, issued in October 1890, upon this subject:—

Resolution of the Madras Government, October 1890.

Paragraph 24.—"It is, however, most necessary to correct "the idea, which prevails somewhat widely, that as soon as a "forest is reserved, cattle and men are to be excluded, and "it is to be worked for the profit of Government rather than "for the benefit of the people. It cannot be too strongly "affirmed that the chief object of the reserved forests "throughout the greater part of the country is the provision "of pasture, small timber, fuel, and leaves for manure or "litter. These are to be worked in order to meet the wants "of the villagers in these respects, and are not to be converted into close preserves for the growth of large timber."

This important Resolution exactly expresses the opinions I had already formed, and it is in the direction indicated that I think future policy should proceed.

The policy of Government.

176. I am aware that changes cannot be effected without expenditure of money, and perhaps a diminished revenue may be the result, at least for a time. But I have attempted to show that the obtaining of a large revenue from the sale of timber may not be coincident with the best interests of the country at large, and that a possible diminution of it may be attended by increased revenue to the State from cultivated land. It has also to be remembered that a very large portion of the revenue of the Forest Department is derived from rich grazing grounds which have been transferred to it from the Land Revenue Department. The Forest Department, in being a revenue-earning one, starts with the following advantage in favour of its old policy as against the one I recommend; that, if timber be sold, the return is an *actual* one, whereas if the plan I advocate be followed, the increase will be a *potential* one; it cannot be directly translated into figures. Nevertheless, I trust I have said enough to show that action in the direction of providing for agricultural wants, and primarily as regards the supply of fuel, is inseparably bound up with the prosperity of the agricultural classes, and with the maintenance of the Land Revenue of the State.

Plantations along canal banks, railway lines, &c.

177. Next to the forests come the plantations which have been established along canal banks, lines of railway, and other selected spots, primarily for the supply of fuel to towns and railways, and not with special agricultural intent. As mentioned in paragraph 163, plantations have been made along the banks of canals in the North-West Provinces and the Punjab, and such towns as Cawnpore, Agra, Rurki, and Delhi are thereby supplied with fuel. It was reported in 1889 that in the North-West Provinces there were 36,037 acres of plantations along the banks of the Upper Ganges, Lower Ganges, Agra, and Eastern Jumna Canals. These are, however, under the control of the Irrigation Department, and not of the Forest Department, and no effort is made to create a local market for the wood; hence it all goes to the large towns, and the plantations are of little local agricultural use. In addition, the system of letting out grazing is by no means satisfactory: in many parts the cultivators arrange among themselves, so that there is no competition for the privilege of grazing, and one man will thus purchase the right of grazing over an extensive area for a merely nominal sum, putting on as many cattle (including his neighbours') as he can and in turn receiving payment from those whose cattle he admits. In other cases grazing is not allowed, but only the cutting of grass. If the working of these plantations were put under a forest officer they would probably be better seen to. Along the Cawnpore Canal the plantations are 40 feet deep; *babul, neem, pepul* and other varieties of *ficus, dhák, sissu,* and *jarman* are the principal trees grown. The native proprietors (*zemindars*) in the neighbourhood sometimes have plantations of their own, mostly of *dhák* and *babul* wood; every three years they cut these over and send the wood into Cawnpore.

Changa Manga.

Changa Manga is a large plantation of 10,000 acres, situated along the North Western Railway, and watered by the Bari-Doab Canal. It was started in 1866, and its object was to provide fuel for the railway. *Shisham (Dalbergia sissu)* is the tree grown, and it is cut on a 15 years' rotation. I found, on enquiry, that the railway company takes the whole of the wood, although only supposed to have that which is above 2 inches in diameter. The smaller wood, 1 to 2 inches in diameter, is re-sold by the railway company. A large quantity of grass, mostly of a coarse nature, grows in the plantation, and to this I shall refer in the next chapter. But I would mention that, so far as I could see, the Changa Manga plantation does not serve any agricultural end whatever, except within a very limited circle. It simply supplies wood for the railway, instead of the latter burning coal. Nearly the same remark may be applied to the Shahdara plantation, near Lahore, established in 1865, and covering 1,254 acres. The river is close at hand, and the soil is moist in consequence; *sissu,* again, is the wood grown. The original intention was to supply fuel for the railway, but now the whole of the wood goes to a contractor at Lahore, for use in the town as fuel. Occasionally a little grazing is allowed, but the forest officers are evidently adverse to it.

These plantations have little agricultural value.

None of these plantations, accordingly, whether along canal banks or elsewhere, serve agricultural ends as usefully as they might be made to do, and improvement in the system of their working is possible. Of course, in one way, they all (except those which, like Changa Manga, are utilised solely for railways) *indirectly* benefit the land, inasmuch as by the increase of the wood supply, even to towns, a certain amount of cow-dung is released which might otherwise be burnt as fuel.

Arboriculture.

178. More agricultural in purport than the foregoing is the system of Arboriculture, the spread of which has been pushed on with commendable energy, mainly by the Directors of Provincial Departments of Agriculture. Apart from a possible influence on climate, the provision of shade and shelter, and ultimately of timber and fuel, cannot but be beneficial. If trees such as the *prosopis,* the *mahua,* and the *jack-fruit* tree, were grown, they would in time of famine be very useful in supplying the people as well as the cattle with food. The fruit of the *babul,* for example, is a very good food for cattle.

Wood-growing in America.

It is very desirable to encourage the planting of trees by private individuals, and to hold out inducements for the doing of this. The feeling of possession, as instanced in the case of a man digging his own well, is one that acts as a strong incentive to agricultural improvement, and it should be fostered in every way. In Prince Edward's Island "arbor societies" are formed with objects similar to the above, and in several States of America special inducements are held out for the taking up of land for the purpose of growing trees.*

"Tope" rule.

To encourage the growing of trees, a "Tope" rule was introduced in some parts of India. According to it, a man was to be allowed land free of rent for 20 years, provided that he grew plantations on it. But the rule was, unfortunately, rendered inoperative, for if another man wanted to grow crops on the particular area he got the preference, and so the rule really was never made use of. I consider that a great deal of good has been done, more especially in the North-West Provinces, by the encouragement of Arboriculture. In 1888–89, *Rs.* 66,989 were spent in the North-West Provinces on Arboriculture, and the receipts amounted to *Rs.* 47,084. In the Central Provinces, during the same year, 29,000 trees were planted. But in Bengal and in Bombay little has been done. In a part of the country where, as in the North-West Provinces, the forests are confined to the hills, and wood and shelter are notoriously deficient, it is of the greatest importance to show the benefit which the planting of trees along roadsides may confer. *Casuarina* is a tree well suited to sandy lands, and the growing of it in parts of Madras has been very successful. In the Native State of Kapurthala, I noticed that plantations of *sissu* and other trees had been made on bare places around the town of Kapurthala, wherever possible. The native landed proprietors (*zemindars*), too, have followed the example set, and in many villages even the common land (*shamilat*) has been planted with *sissu* and *babul*, wells are surrounded by trees, and mango trees are planted along watercourses; some villagers have even planted small gardens, and the State, as an encouragement, remits the revenue of all such lands. In driving along the road from Jullundur to Hoshiarpur I frequently saw *sissu* trees which had been planted by *zemindars* in blank patches of the fields just off the roadside.

Undesirable to plant trees close to cultivated fields.

It is well, however, that I should here interpose a caution as to the undesirability of planting trees, more especially *babul*, close to the edges of cultivated fields, at least where cold-season (*rabi*) crops are grown. The roots of the trees run out in search of moisture and nourishment, and thus deprive the crop of each, especially the former. I have seen numerous instances of a *rabi* crop being damaged in this way; with rainy-season (*kharif*), crops and where there is abundant rainfall, it does not, however, matter.

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* This is done under an Act known as the Timber Culture Act. A period of eight years is given during which to raise 10 acres of trees on a 160-acre holding. It must be shown that the timber is to be cultivated for the exclusive use and benefit of the applicant, and not for the purpose of speculation, or for the use and benefit of other persons. An entry fee of $14 (2 *l.* 16 *s.*) is paid, and a like sum at date of final proof. If, at the conclusion of the term, at least 675 thriving trees can be shown per acre, a title deed to the land thus planted is given.

The need of creating more "reserves."

179. But, after all, and even were the existing "reserved forests" to be devoted, where possible, more to agricultural ends, there would not be enough reserved areas to meet the demand. The "reserved forests" can only serve a certain circumscribed area, and there must yet remain, especially in the North-West Provinces, large tracts where trees, much less forests, are almost unknown. It is in such districts, untouched by forests, that the endeavour must be made to *create* "reserves." It is hardly necessary to say much in proof of the above, the fact is almost universally *admitted*. The following instances, gathered in the course of my tour, may, however, be usefully given, as showing the scarcity of firewood, and that the price of it is more than the cultivators can afford to pay in order to replace cow-dung by wood for fuel.

Instances of the scarcity of firewood.

North-West Provinces.

At Cawnpore the price of firewood is 4 annas per maund (80 lbs.), or 1 rupee for a little more than 300 lbs., whereas 100 pieces of sun-dried cow-dung cakes (*bratties*) only cost 2 annas, or 1 rupee for a whole cartload, weighing some 700 lbs., about three cartloads going to the ton.

At Rurki, which is supplied from the canal plantations, firewood costs *Rs.* 22 for 100 maunds, making the price 3½ annas a maund, or much the same as at Cawnpore.

Punjab.

Ferozpore is very badly off for firewood, especially along the riverside tracts. The land here wants a lot of manure, and the people are well aware of this, but have little to spare owing to their being obliged to burn it for fuel.

Bombay.

In the Deccan, and in the Southern Mahratta country, wood for implements is specially scarce.

In Bombay itself, firewood costs *Rs.* 2 for 10 maunds (80 lbs. each).

At Poona it is very much dearer, and especially hard to procure, inasmuch as it has to be fetched 30 or 40 miles. The cost in Poona is 8 annas a maund, or *Rs.* 5 for a cartload, whereas a cartload of dried cow-dung cakes (*bratties*) costs *Rs.* 3, and a cartload of loose cow-dung 1 rupee only.

Ahmedabad also is badly off in this respect; the maund here is only 40 lbs., and 1 rupee will purchase only 4 maunds of firewood, or 160 lbs.

At Mahim firewood has to be fetched from the forest; this implies a three days' journey there and back; the cost for a small cartload is 8 annas.

The cost at Belgaum is *Rs.* 2 to *Rs.* 3 a cartload, but it has to be fetched from a distance of eight miles off.

Coorg.

Even at Mercara, where the Coorg forests are not far off, firewood costs *Rs.* 3 a cartload; and at Hunsur, the depôt of the Coorg forests, the charge is *Rs.* 3 per ton. It has, however, to be carted 18 miles, at a cost of 14 annas a ton more, before it can be of any use to the cultivators.

Madras.

A cartload of 1,000 lbs. of firewood costs *Rs.* 2½ at Shiyali, and at Madura a bandy-load (three to the ton) sells for *Rs.* 4 to *Rs.* 5, but it has to be brought some 20 miles.

Mr. Benson, writing about Bellary, says:—

"The supply of cattle-manure is small, except in a few places, owing to "the scarcity of wood for fuel. One of the greatest wants of the district "agriculturally is a better fuel supply, and this is an object which is worthy "of the most careful attention."

Mr. Nicholson says of Karúr :—

"There are no forests or jungle. A great deal of planting of hedges and "trees is still needed. Fuel is dear, *palmyras* scarce, and building timber is "brought from Pálghát at great expense. . . . . . . At Pollachi firewood "costs *Rs.* 2 to *Rs.* 2½ per cartload, the nearest available jungles being 10 "and 12 miles distant."

Bengal.

Mr. Basu writes thus of Chota Nagpur :—

"The mass of the people are too poor to buy fuel. No improvement "under the head of burning dung will take place until fuel is rendered cheap "and accessible. There are no fuel reserves belonging either to Government "or individuals. Around Rauchi firewood is scarce and jungles inaccessible."

I could multiply these by a great many other instances which I have met with myself, or which I have collected. In Chapter VII., paragraph 123, I have already shown that wherever wood is sufficiently plentiful it and not dung is the general fuel, and that manure being thus set free for the land, the cultivation has benefited immensely; such instances are Nadiad, Hospet, Avenashi (Coimbatore), Hoshiarpur, Multan, and many others.

As affording a contrast to the remark made above by Mr. Benson on the scarcity of wood in Bellary, another quotation from that gentleman, when speaking of Cuddapah, will illustrate my point well :—

"The abundance of fuel in the neighbourhood prevents the use of *bratties* "extensively for fuel, so that the soil receives a good deal of what is removed "from it by the crops raised."

The need is best met by the creation of "Fuel and Fodder Reserves."

180. Having instanced sufficiently the need of more firewood for agricultural purposes, I must now express my concurrence with the views that have been expressed both by Governments and by individuals, that the way in which the supply of wood to agriculture can be best increased is by the *creation* of new enclosures of land for the purpose of growing wood, scrub, jungle, and grass. Such enclosures are now denominated "Fuel and Fodder Reserves."

I shall indicate briefly what has been done in this direction, and then try to point out in what way extension or modification of the system is called for.

Opinions in favour.

The establishment of "Fuel and Fodder Reserves" was advocated successively by Sir D. Brandis in 1873, by the Famine Commission in 1879, and by the Government of India in 1883, acting upon the recommendations of the Famine Commission (*see* paragraph 163).

Sir Edward Buck.

Sir Edward Buck, when an officer in the North-West Provinces, warmly advocated the establishment of these "reserves," and to him is mainly due the initiation of experiments on their formation over ravine lands and salty land (*usar*) plains in the North-West Provinces (*see* paragraph 75).

Mr. J. B. Fuller.

Mr. J. B. Fuller, writing on the subject in 1887, says :—

"The desirability, in the interests of the people, of establishing fuel and "fodder reserves is admitted on all hands."

The Madras Resolution, Oct. 1890.

More recently (October 1890) the Madras Government issued the important Resolution on the policy of their Forest

Department, to which reference was made in paragraph 175, and from which I will now further quote:—

Para. 6. "The question of the provision of fuel is hardly "less important than that of pasture. In many parts of "the Presidency the supply of firewood is so scanty that "the people suffer considerable inconvenience and discomfort. "But this is not the worst; wood being dear, the dung of "cattle is used in its place, and the soil is thus deprived of the "manure of which it stands in such urgent need. Any "measures, therefore, which tend to improve the supply and "lower the price of firewood would be of immense advantage "to the cause of agriculture in this country."

Para. 7. "For the reasons set forth in the preceding "paragraph, his Excellency in Council is of opinion that the "establishment of fuel and fodder reserves is most desirable "in the interests of the cultivating classes."

Para. 24. "Further, the Government advocates, if the area "already taken up is not enough to furnish the estimated "requirements in firewood, leaves, and small timber, and to "afford grazing for all cattle necessary for agricultural or "domestic purposes, more land should, if possible, be brought "under management, and the natural jungle growth should be "supplemented by plantations created for the purpose of fuel "supply."

In the above extracts is contained the acknowledgment that the supply of firewood is still very deficient, and that existing resources are not enough, but that new reserves will have to be *created*.

"Fuel and Fodder Reserves" already created.

181. We will now see what steps have been taken in this direction since Sir D. Brandis and the Madras Government moved in the matter, and since the Government of India proceeded to act upon the recommendations of the Famine Commission.

Patri forest, Rurki.

The earliest "Fuel and Fodder Reserve," in the strict sense, that I can find mentioned is the Patri forest, near Rurki, North-West Provinces. This plantation was begun in 1871, five blocks, comprising in all 80 acres, being demarcated, and trees, mostly *sissu*, being planted and watered by a cut taken off from the Ganges Canal. Sir D. Brandis reported in 1881 that it was doing well. He suggested that it would be necessary to keep out cattle at first, but by and by to permit grazing in protected blocks, admitting only certain villages and making them responsible for the protection. This practically was of the nature of a "village forest," and was agricultural in intent.

Ajmere-Merwara.

The forests of Ajmere-Merwara, although of large extent and under the Forest Administration, are really "Fuel and Fodder Reserves" on a large scale. I have shown how the Government of India were able to deal with them straight away, having a direct control over them. As I have said, they more nearly approach to my idea of what "agricultural forests" should be than anything else which I have seen or read of under the Forest Administration. My complaint is that there are *not enough* Ajmere-Merwaras. I allow fully the benefit of what has been done there, but there ought to be more "reserves" like these. The answer of the Forest Department is, that the difficulty of getting land is so great, and it is seldom that land can be found which, as at Ajmere-Merwara, is under direct Imperial control. This is quite true, but when I see what has been done, as I shall tell later, in taking up land at Etawah, Jhansi, Aligarh, and Cawnpore, as well as in the plantations of Shahdara, Changa Manga, and along canal banks, I cannot think the difficulties insurmountable; and if the Forest Department had been more alive to agricultural needs, and less anxious to show large financial returns, more might have been done in forming other "Fuel and Fodder Reserves" like Ajmere-Merwara.

Sir D. Brandis started the Ajmere reserves in 1873, by taking up and protecting the then bare hills lying around one side of the valley, where the town of Ajmere is. The hills on the other side were left as they were, and were not included in the operations, but were left free for whatever grazing or cutting of wood they could supply.

The villages included in the reserved part were handed over to the Forest Department, who allowed the villagers to cut and remove grass from November to February, and to have grazing from March to June. Further, the villages were to receive two-thirds of any surplus revenue and all the grass. No planting was done, but grazing was prevented, except in specified parts, and wood was only cut as allowed. No regular enclosure was adopted, *euphorbia* hedges and stone walls only being put up here and there. In a few years there was a complete transformation, the bare hills soon clothing themselves with small trees and scrub, while grass sprung up in abundance.

In 1881 Sir D. Brandis wrote in reference to them:—"In all, except the "most arid tracts . . . . mere protection, aided by sowing and planting "in suitable places, will gradually clothe grounds with trees and shrubs."

I visited the reserves around Ajmere, and I found them to be as had been pointed out to me; the protected hills were green and covered with trees, shrub, and grass; the hills on the opposite side of the valley were barren and unclothed. The contrast presented was a most striking one, and no one could see it without being impressed with the change that simple enclosure could effect, even on a thin and rocky soil such as that on these Ajmere hills. Undoubtedly, too, the covering of the surface with vegetation has helped greatly in preventing denudation and surface-washing, and has thus contributed to the formation of soil, and the retention of the rainfall.

The principal trees are *zizyphus*, *anogeissus*, and *babul*, and a considerable sale of dried and dead *euphorbia* bushes is also effected.

The work of protection has not been confined to the hills around Ajmere known as the "Nagpahar forests," but another hill slope near the town, and called the "*Mohwa bir*," has been taken in likewise. Here the soil is thinner and more stony than ever, and it seems a wonder that anything whatever will grow on it. Yet, although little grazing can be afforded, a good quantity of grass is cut, and *zizyphus* and *babul* trees grow very fairly.

From Ajmere I went to see the "Chang reserve," another one forming part of the Ajmere-Merwara forests, and about six miles from Biawar. This was begun in 1875, and comprises 3,000 acres. Here, again, the contrast between the protected hills and the unprotected ones was most marked. A great deal of firewood is cut by contract, and carted to Biawár, 2,400 camel-loads (480 lbs. each) and 6,572 head-loads of small fuel coming from the "reserve" in the course of the year 1888–89. No attempt is made to grow large timber, but in the better parts *neem* seed is dibbled, and this tree does very well. Reproduction goes on very satisfactorily indeed, and protection from fire and trespass is well maintained. The grass is, as a rule, cut and removed, but the forests, in time of drought, are thrown open to grazing.

Similar "reserves," which I had no time to visit, lie nearer Merwara. The whole area comprised in the Ajmere-Merwara forests is 89,264 acres. In 1889–90 six areas of village lands, 4,395 acres in all, were voluntarily made over by the people to the Forest Department for management by them, and were constituted "village reserves." To show the value of the Ajmere-Merwara forests, it may be said that, in 1889–90, owing to failure of rain and scarcity of fodder, nearly all the reserved area was thrown open to grazing during part of the year, and no less than 14,684 head of cattle were allowed in. The fire lines (dividing the "reserves" into isolated blocks for preventing the spread of accidental fires) are burned by the people in return for the grass removed.

I have mentioned the case of the Ajmere-Merwara forests rather at length, as it is the best example of what should be tried elsewhere. The financial result at the present time shows that expenses have just been met, but, to my mind, the good that has been done, but which cannot be actually translated into figures, represents a very considerable surplus. The mere supply, to an agricultural district such as this, of wood to replace dung as fuel must be highly beneficial, and would be even more so did not Ajmere labour under the difficulty of a very uncertain and often failing rainfall.

My other instances of Government experiments must be drawn from those on ravine and salty (*usar*) land, for I have already spoken of canal plantations and others, such as Shahdara and Changa Manga, and have shown that their ends are not, in the main, agricultural ones. Even ravine and *usar* lands I have previously fully dealt with in Chapter V., paragraphs 70–76, and need say little more about them now.

Etawah, Jhansi, Cawnpore, and Awa are the chief places where tree-planting has been tried to any considerable extent, for on the *usar* land at Aligarh it has only been done on quite a small scale, and the efforts have been confined mainly to grass and crop-growing. I may here point out the financial success attending the enclosure of ravine land at Etawah. Etawah.

About 4,400 acres (7,000 *bighas*) of this land belonged to the native landowners (*zemindars*), and the area was of but little use except for cattle to roam over. In 1885 the Agricultural Department of the North-West Provinces persuaded the *zemindars* to let it try the experiment of tree-growing, and got them to advance *Rs.* 600 for planting *babul* seed over the land. Cattle were kept off, *babul* seeds were scattered broadcast just before the rains came, the trees came up capitally, the grass grew well, and soon, without any artificial irrigation, a useful "fuel and fodder reserve" was formed out of what had been simply waste land. The "reserve" now brings in an annual income of *Rs.* 1,100, and the *zemindars*, never having parted with the land, take care to keep the proceeds too. Now, had Government done what it might have done and bought the land outright, the continuance of the "reserve" might have been secured, and the income also. As it is, the care of the "reserve" is practically in the hands of the Collector of the district for the time being; he may take an interest in it, as Mr. Fisher (who originated it) and Mr. Alexander (his successor) have, but should he not happen to do so, the entire good may be destroyed.

This instance shows, however, how much may, with care, result from an expenditure of *Rs.* 600 only. Similar ravines to those at Etawah extend along both banks of the Ganges and Jumna, and what has been done at Etawah might be followed elsewhere, with great advantage to a Province so destitute of wood as the North-West Provinces are.

In regard to ravine and salty (*usar*) land, a careful investigation was made in 1883 in the Doab district of the North-West Provinces, by Messrs. W. J. Wilson and Darrah, when it was ascertained that *usar* land could be had in abundance; also that there was a certain amount of ravine land available for "fuel and fodder reserves," the average purchase price of

Ravine and *usar* land in North-West Provinces.

both of which would come well within the limit suggested by Government as the price of purchase, viz., *Rs.* 20,000 for 10 square miles. After making calculations which were purposely put more unfavourably to the scheme than was necessary, Messrs. Wilson and Darrah concluded their Report by saying:—

> "On the whole it appears probable that plantations in the ravines will "yield a very considerable profit, and with *usar*, too, both grass and trees "will pay expenses."

It was pointed out that, while doubtful whether any effect would be produced on the climate, it was certain that erosion of the soil would be prevented in ravines, and that a layer of *humus* would be accumulated on *usar* soil, whilst in times of drought the loppings of the trees would be of great value. The Report says:—

> "The financial loss, if it occurs at all, will be trifling, and the advantages "of protection of land from erosion, and protection of cattle in drought, "would well warrant the expenditure."

That the opinion formed was a correct one is exemplified by the result of the Etawah enclosure.

Of the success which may be achieved by growing trees on salty land, the instance of the Phagwara *tahsil*, in the Kapurthala State, given in Chapter V., paragraph 75, affords proof.

Usar land at Kapurthala.

The 9,000 acres taken up included 7,660 acres that were not fit for cultivation, owing to the soil being impregnated with soda salts (*kalar*), *usar* land, in fact; yet the *dhák* tree (*Butea frondosa*) grows here capitally, supplying 40,000 maunds of fuel annually. The sale proceeds from this and from grazing fees amount to *Rs.* 9,000 per annum, with an expenditure of only *Rs.* 540. The growing of *dhák* has one great advantage in that cattle, sheep, and goats will not touch the tree, and consequently grazing does not harm it.

The growing of *dhák* ought certainly to be much more extensively tried on *usar* land, especially seeing what quantities of such land there are in the North-West Provinces alone. The experiments made up to now on *usar* land have been directed mainly to enclosing and growing grass on it. I should like to see the growing of trees tried more extensively.

Forest Department too much engaged in settling "Reserved Forests."

182. The question was often asked by me, why the Forest Department has not created more "Fuel and Fodder Reserves." The answer most generally given was, that the Forest Department is still busy over the "settling" of the "Reserved Forests," and that as soon as this is done it will go on to deal with the "Village Forests," which these "Fuel and Fodder Reserves" would virtually be.

Undoubtedly, progress is hampered by an insufficient staff, but I consider this important question must not be longer delayed.

The reservation of land for communal purposes.

183. It has been rightly said that one of the curses of the country is the indiscriminate granting of land without the reservation of land for communal purposes. I notice with satisfaction, therefore, that Government, in giving grants of land near Multan, along the Sidhnai Canal, have reserved about 10,000 acres for "forest reserve," and that, where the Sidhnai irrigation extends, the lessees may use the trees or brushwood, but may not sell nor exchange it.

The practical difficulties in obtaining land for the creation of "fuel and fodder reserves."

184. Having now established not only the usefulness of "Fuel and Fodder Reserves" where they have been formed, but also the need of more of them, we have to consider the two practical difficulties which have been put forward by those who have even allowed the desirability of the extension of "reserves." These are:—

Firstly, the difficulty of finding land suitable for the purpose.

Secondly, the difficulty of acquiring it even if suitable.

These will have to be treated separately.

Considerable amount of land available.

185. As to a considerable amount of land being available, there can be no doubt to anyone who has gone over the country.

It is, however, true that where wood is most wanted there the land is mostly taken up by cultivation, and wood can only be purchased at high rates, but that where wood grows freely there is no cultivation to demand it urgently.

The North-West Provinces and many parts of the Punjab afford instances of the scarcity of wood. In the North-West the plains are, generally speaking, fully and even densely cultivated [except where salty land (*usar*) exists], whilst the forests are confined to the hilly regions on the northern boundary. In Bengal, too, it would only in certain parts be possible to extend the existing forests to the more cultivated areas. In Madras and Bombay, on the contrary, it would be quite possible.

Classes of land available.

186. Reserving to the next section the consideration of the way in which lands are to be acquired, I may here name the classes of land which might be available.

(*a*) The waste land belonging to Government whenever a *raiyatwari* settlement exists, and including (in the case of Madras, at least) the sides of roadways, channels, tanks, embankments (*bunds*), beds of streams, &c. (*b*) The waste land of villages (at least when in excess of village requirements) and other uncultivated areas. (*c*) Salt plains and salt patches (*usar* land). (*d*) Ravine land. (*e*) The banks of canals and railway lines. (*f*) Land at present under dry cultivation, but which it might pay better to convert into "reserves."

In illustration:— Instances.

(a) Government waste land.

(*a*) In Madras the waste land all belongs to Government. Mr. Nicholson reported in 1887 that in the Anantapur district alone there were 1,141,089 acres of Government waste land, and that there were parts where blocks of 1,000 acres could be dug round, enclosed with banks, and then seeds of trees be sown before the rains.

In his "Manual of Coimbatore" Mr. Nicholson mentions places, such as Karúr, Dhárápuram, Kúgalúr, Palavapálaiyam, Nambiyúr, Udamalpet, and elsewhere, where fuel reserves are needed and might be established. Of Karúr he says :—"the channel and river banks might be planted with "advantage . . . . the *taluk* is poorly wooded . . . . even the most "favourable positions, such as channel banks, deep spots near water, &c., "are not utilised . . . . there is one private jungle, but this is left to "nature and not assisted by plantation . . . . it produces *babul* trees and "grass abundantly."

Mr. Benson found in Kurnool (Madras) large tracts along the foot of the Nallamalais, which would be suitable for "reserves."

Around Salem the hills are not fit for cultivation, but would make good "reserves."

I noticed myself, when travelling in the Madras Presidency, many channel banks, sides of tanks and roadways, where trees might have been planted.

When enquiry was made in the Madras Presidency in 1883 it was found that, taking the whole Presidency, 100 acres of land to every village in a *taluk* were available for "fuel and fodder reserves."

In the Central Provinces, in one *tahsil* alone of the Sambalpur district, waste areas of over 6,000 acres were found, which had remained the property of Government, and thus were available for conversion into "fuel and fodder reserves."

(*b*) Village waste and uncultivated areas.

(*b*) It is a question how far it is advisable to take up waste belonging to a village, but in the Punjab and in the Central Provinces, the latter principally, there are village lands which are considerably in excess of the people's requirements. The Lieutenant Governor of the Punjab concurs in thinking that land in excess might be turned into "reserves." Between Lahore and Amritsar I noticed uncultivated areas in abundance, and wherever trees occurred they grew very well.

Between Agra and Gwalior I saw a lot of uncultivated land.

In Bengal Mr. Finucane found that there were some 37½ square miles in the Rhotas and Rehul plateaus of the Khymore Hills which might become "fuel and fodder reserves." The Bengal Government further authorised the purchase of 1,200 *bighas* of land belonging to the Deo Estate, and in Sasseram other areas were proposed. The Deputy Conservator, in reporting on them, said :—"I do not think any site could have "been selected more suitable for the formation of fuel and fodder "reserves." The financial prospects, derivable solely from annual licenses granted to villages, were stated to be very promising.

Between Bettiah (Behar) and the Nepaul frontier are strips which might be "fuel and fodder reserves." This land belongs to *zemindars*, and would have to be obtained by purchase.

Also, near Segowlie (Behar) is a good deal of waste land, it having fallen out of cultivation during the famine of 1865.

The report of the Bombay Agricultural Department for 1886–87 speaks of "much land both in riverside villages and others eminently fitted for "*babul* reserves," and the Bombay Government has given remission of three-quarters of the assessment to applicants willing to devote land to the extension of *babul* plantations, or to take up new land for it.

Such villages are some near Ahmedabad, Nasick, and Poona.

In Mysore I observed large stretches of land between the towns of Mysore and Hunsur which were not cultivated, but on which large amounts of firewood might be grown. In the centre of Mysore, near Arsikeri and Hassan, are large tracts that might be enclosed and made into "fuel and fodder reserves."

(*c*) *Usar* land.

(*c*) The vast range of salty (*usar*) plains and patches in the North-West Provinces has been mentioned (*see* paragraph 181). Others occur in the Punjab, the Deccan, the Southern Mahratta country, parts of Madras, and elsewhere. Between Delhi and Rewari is salty land on which the tamarisk bush grows well.

(*d*) Ravine land.

(*d*) The ravines along both banks of the Ganges and Jumna rivers have been referred to (*see* paragraph 181).

Sir Edward Buck, in a note on the Muttra Settlement, speaks of the feasibility of introducing "fuel and fodder reserves" along the Jumna Valley tracts, and points out that the experiments made at Ajmere and elsewhere "prove that under proper management large areas will be "available for trees and grazing which are not susceptible to ordinary "cultivation."

Ravine land occurs largely at Pahara, near Mirzapur, North-West Provinces.

(*e*) Banks of canals and railway lines.

(*e*) The Administration Reports of the Central Provinces speak of there being always areas for brushwood on banks, beds of streams, &c.

The Bombay Agricultural Department Report for 1888–89 regrets the great opportunity which was lost in not securing stretches between Hubli and Gadag, along the Southern Mahratta Railway, and on which *babul* grows splendidly.

The Bengal Agricultural Department Report for 1889–90 says that it had been ascertained that along the Assam-Behar, the Tirhoot extension, and the new Chittagong-Assam lines "fuel and fodder reserves" could be made.

(*f*) Land of dry cultivation.

(*f*) It is quite certain that there are many stretches of dry cultivation where crops are taken only occasionally, it may be once in three or four, or even once only in six years, but which could be much better utilised by turning them into "fuel and fodder reserves."

About 1,400 acres of such land exists at Máhim (Bombay), and is not worth 1 anna an acre for rent.

At Avenashi (Coimbatore) is also a lot of dry land, assessed at 1 rupee per acre, which might grow trees well. This is also the case in Cuddapah.

In parts of the Deccan, where wood for implements is very scarce, the growing of wood, even if not directly remunerative, would be a great boon to the cultivators.

Mr. Fuller thinks that in the Central Provinces it would be good if Government were prepared to remit the revenue of a few fields in certain villages, on condition that the proprietors planted and maintained trees on roads running through it.

Experiment at Bhadgaon on growing a plantation.

I might here refer to an experiment now being carried out by Mr. Ozanne, at the Bhadgaon Experimental Farm of the Bombay Government. In June 1888 Mr. Ozanne sowed eight acres of cultivated land with *babul* seeds put in furrows; one-half of the area has had no artificial watering whatever, the other half only one watering, viz., in the first year. The interspaces between the rows have been sown with crops of *bájra*, gram, &c. At the time of my visit, in August 1890, the plantation was growing well, some of the best plants were 4 feet high, and the plantation had cost nothing whatever, the crops grown between the rows having paid all the expenses.

It is very clear, from the instances I have given, that there is a good deal of land on which "fuel and fodder reserves" might be formed, and if only systematic enquiry be made it will result in showing, as Messrs. Wilson and Darrah's experiment in the North-West Provinces did, that there is very much more land available than has been stated.

In almost every district there are uncultivated spots among existing cultivation which would grow *babul* or similar wood perfectly well. Although it may not pay Government to take up these plots, yet, if the example of tree-growing were set, encouragement would be given to native proprietors (*zemindars*) and others to adopt the plan also.

How to acquire land.

187. Having dealt with the difficulty of finding land, the second one, that of how to acquire it, must be taken.

According to the ownership and the terms under which land is held, so will the procedure to be adopted vary.

No difficulty with Government waste land.

Where waste land, as in Madras, is the property of Government there is no difficulty whatever, and, as we have seen, under the term "waste land" is included much land, such as the beds of tanks, &c., which is not available in other Presidencies. The matter for regret is, that, with the exception of Madras, and possibly the Central Provinces also, the amount of waste land still left is very small, but where there is any, and so placed as to be of probable benefit to the people if it were turned into a "fuel and fodder reserve," such land should be thus converted.

Reservation of trees grown on tank beds, &c. for local use.

There is one provision I should like to see made, viz., that when trees are grown on waste land, such as the beds of tanks and streams, &c., the wood should be devoted *primarily* to the use of the people *around*, and that the trees should not, as is at present the case, be periodically cut down *en bloc* and be sold by auction to the highest bidder, often being taken far away from the district. A period then elapses until the fresh trees that spring up are ready again to be cut. These plantations (they are mostly of *babul*) should be kept for the wants of the district where they grow, becoming thus really "village plantations," and they should not be cut down in one mass. The natural reproduction should also be meantime looked after.

The village waste, should it be acquired?

This not advisable as a general rule.

188. Next comes the vexed matter of the "village waste," and whether it should be taken up by the Forest Department and worked for the people's benefit. This could not be done without, for a time at least, keeping the cattle off and excluding the people from any use of the land, until the "reserve" was fairly established. Where the "waste" actually belongs to the people, it is, I must say, a doubtful policy to interfere with the people's time-honoured rights, and they can hardly be excluded from them without considerable friction being caused, which it is well to avoid. At the same time, as I shall show in the next chapter, the value of the "village waste" is greatly exaggerated, and I am doubtful whether it is not productive of more harm than good. Practically, as feeding areas the "village wastes" are worthless in nine cases out of ten, and serve little purpose beyond that of providing standing room and exercise ground for half-starved herds. Nevertheless, it would be very risky to interfere with prescriptive rights, and, if it is possible, it is better to avoid dealing with the "village waste." What may, however, be hoped for is, that in the more advanced parts the people, after seeing the good which "reserves" have effected in other parts, will enclose it, or a part of it, *on their own account.* That there is hope of this being done is exemplified by the instances of Etawah, Ajmere, and Kapurthala, already recorded. In these cases land belonging to private individuals and villages was voluntarily handed over to be worked by Government as "fuel and fodder reserves" (*see* paragraphs 178 and 181).

Possible case where acquisition of village waste is desirable.

The one case in which "village waste" might be directly dealt with is where the amount of waste land is manifestly in excess of the requirements of the villages. This occurs frequently in the Central Provinces, and also in parts of the Punjab. The difficulty of taking up waste belonging to a village is, that only that particular village could share in the privileges, whereas if the land be Government land, or be acquired by purchase, it would be available for as many villages as it could serve. Again, the existence of rights in an enclosed area may hamper future action, and render the dealing with these rights a matter of difficulty.

On the other hand, it may often be the case that, in order to be of any use to the villages as supplies of fuel, these " reserves " will have to be near the villages, and in many parts, therefore, the only way to establish them will be to appropriate portions of existing village wastes or commons.

189. The suggestion to form " village forests," which should include the village grazing grounds and be protected and managed by the people themselves, was made by Sir D. Brandis, but the efforts to establish them have successively failed. In the Indian Forest Act (1878) a chapter (Chapter III.) was inserted to provide for the assigning of the rights of Government to or over any land constituted a " reserved forest," and for calling it a " village forest." This chapter has, however, been quite inoperative, owing, I am informed, to the impossibility of determining adverse rights, and of separating the rights of the community from the private rights of native proprietors (*zemindars*) and others. Often, for instance, there may be several *zemindars*, and thus several people to settle with. Anyhow, no " village forests " have been taken up or assigned under this chapter, which is accordingly a dead letter.

" Village forests."

Failure of attempts to create them.

Indian Forest Act.

In 1886 an attempt was made to amend the Land Revenue law of the Punjab, by inserting a fresh chapter (Chapter VIII.) to read as follows :—

Land Revenue law of Punjab.

" If the majority of the landowners desire, or the Local " Government considers it expedient, that part of the common " waste lands of an estate be managed for the production of " timber, fuel, or fodder, the Local Government may proclaim " that any part not exceeding one-fifth shall be so managed."

Expressions of opinion were invited on this suggestion, and, while a general agreement was come to as to the value of such a measure in the interests of the people, it was felt that there would be difficulty in the procedure, and in compulsorily dealing with the village waste. The introducer of the Bill, the Honourable Colonel Davies, on bringing it before the Viceregal Council in July 1886, said :—

> " There can be little doubt that a power of this kind is very much " wanted, in the interests of both the State and the people ; and, from my " own experience, I think I may confidently state that in many parts of the " Punjab the intervention of Government to bring about the results aimed " at by this chapter will be welcomed by the people."

The Secretary of State, however, on the matter being referred to him in November 1886, considered Chapter VIII. as an innovation, and that interference in the internal affairs of villages might possibly be distasteful to the communities concerned, so he expressed the hope that the reply would be very carefully considered.

The subject was thereupon dropped for the time.

Madras Resolution of Oct. 1890.

The Madras Government, in their Resolution of October 1890, already alluded to, discussed this matter and the various efforts which had been tried. Their opinions were expressed as follows:—

Para. 23.—"The Madras Government now (October 1890) " is of opinion that the idea of village forests must be alto- " gether abandoned; that it is desirable to have the sources " of fuel and fodder supply under Government control, and to " have the reserves in fairly large blocks."

Government and not communities must have control of all forests.

It is a mistake, I think, to assign any rights to a village community, and to have "village forests" managed by the community uncontrolled. The tendency of our system of government has, to a considerable extent, been to *break up* village communities, and now for the most part they are heterogeneous bodies rather than communities. What is wanted is, while retaining control over these forests, to work them for the people's interests.

Provision in Central Provinces to "control common user."

190. Short of actually purchasing land outright, there is a provision in force in *malguzari* tracts, such as the Central Provinces, by which the proprietor (*malguzar*) may be called upon to use excess waste land for the common good.

Central Provinces.

In the Settlement of the Central Provinces it was stipulated that the rights of ownership to forest land would be subject to restrictions in the interests of the village communities, and of the country as a whole. Tenants were to retain their customary rights of "user," and Government had the power of prescribing rules to prevent reckless clearing of land and sale of all the timber.

In the Central Provinces Administration Report for 1887–88 it is said:—"The increasing value of jungle produce leads " *malguzars* to advance claims of exclusive right to the use of " village wastes and forests, and they sometimes cut down " and sell all the timber of their village. This is opposed to " the principles of *malguzari* settlement. *Raiyats* have a " right to the use of the village waste for grazing, and a right " to cut wood in the village jungles for firewood and agricul- " tural implements."

Extension of such provision desirable.

Such a provision is, in effect, an Act to "control common user," and the extension of it to other tracts might be usefully employed for the purpose of preserving the fuel supply of villages. In Bengal and other *zemindari* tracts an Act might, accordingly, be passed to lay the obligation on the proprietor to grow firewood, and to preserve these supplies for the common good.

The shortest and probably the best way, however, in *zemindari* tracts is for Government to step in and buy the land outright.

191. It is a question, I believe, whether a simple ruling of Section 6 of the Land Acquisition Act could be taken to include the formation of areas for "fuel and fodder reserves," or whether the Act would have to be amended so as to include the formation of these. This is a point I can express no opinion upon, except that it is very desirable that Government should be able to purchase land with this object in view. The amount of Government waste land, though sufficient perhaps in Madras, is, for the most part, manifestly deficient elsewhere, and the acquisition of fresh land is undoubtedly called for in order to supply the proper amount of fuel required.

Land Acquisition Act.

192. I am far from advocating the covering of the country all at once with "village forests." Whatever is done must be done carefully, and at first experimentally; even where a large area of land is available, it may be better to take up only a portion at first, and to extend it if successful. But the plan should be given, what it has not yet had, a fair trial.

The work of afforestation must be done gradually.

By enquiry alone can it be ascertained whether there are any purchasable areas, and whether they would be suited for the purposes contemplated. No general rule for purchase can be laid down; all depends upon where and what the land is, and what it costs.

Enquiry is needed to ascertain areas suitable.

193. Where land has to be purchased, it is recognised that, as soon as this fact is known, absurdly high prices are asked, although the land may be bringing in next to nothing.

Estimate of cost of land purchased.

The estimate of the North-West Provinces Government was, that, so long as land did not cost above *Rs.* 20,000 for 10 square miles, or a little above *Rs.* 3 an acre, it would pay to buy it, and, as has been stated, when Messrs. Wilson and Darrah came to enquire, they found far more land available and purchasable within the price fixed than had been expected. Further, they found that the financial prospects were fair, even after making calculations unfavourable to the scheme. The estimate of cost, it should be said, included that of fencing with stone uprights and barbed wire.

In the North-West Provinces there is almost any quantity of salty land (*usar*) available, but its frequent occurrence amidst cultivated land adds to the cost of purchasing blocks which include cultivation, and to the expense of enclosure, which would then be necessary. Still, there are many tracts which are entirely *usar* land.

In the Central Provinces, Government is generally able to purchase unculturable land at 1 rupee per acre, and culturable though uncultivated land at *Rs.* 2 per acre, so that here, where cultivation has not as yet pressed on the land, the problem of obtaining land for "fuel and fodder reserves" is not a difficult one.

That land could be taken up at this rate and worked profitably there can be little doubt, judging from the expe-ments in the North-West Provinces, where the purchase price was *Rs.* 3 an acre.

Practical details in working of "fuel and fodder reserves."

194. Some practical details may now be mentioned in the working of those "fuel and fodder reserves" which will have to be *created*, either by the taking in of waste land or by the purchase of fresh land.

Size of area.

The area to be taken up should not be too small; a minimum of 100 acres, or possibly 200 acres, should be fixed, unless there are a number of small blocks close to one another, for which one and the same supervision would suffice. There is not, I think, need of permanent enclosure or fencing, and guards (*chowkidars*) should suffice for the purpose. Even should a stray animal find its way in occasionally, the harm done will not be great, and the owner would be liable to have his privileges forfeited if the act were repeated.

Enclosing not requisite, as a rule.

Even if enclosure were found necessary it would be quite feasible to enclose a portion at a time, and by growing a live hedge behind the protection of a barbed-wire fence, the latter could be moved on as the hedge became established. In this way successive areas of 20 acres at a time might be taken up, until the whole "reserve" was formed. It is only where small blocks occur in the midst of cultivation that the necessity of fencing is likely to arise, and then a small mound and ditch will answer best, unless it be where thorn, *babul*, cactus, prickly pear, aloe, *euphorbia*, or other hedge material will grow readily.

Cost of enclosure, when requisite.

Aloe hedges and earth walls occur near Mysore; stone walls are used in the Deccan; at Dumraon a hedge of *euphorbia* enclosing 15 acres of land took three to four years to establish itself properly, and the cost of throwing up an embankment all round the area, and planting the hedge, was *Rs.* 53 only.

At Gursikran, near Aligarh, 718 acres of salty land (*usar*) are enclosed merely by a small ditch and low mound, and the cattle do not get in at all. Mr. W. B. Hudson gave me particulars of some enclosing which he had done. He made a ditch with sloping sides 6 feet wide at the top and 2 feet at the bottom, the earth being thrown up to form a bank on the top face of which thorn is planted. The whole cost was *Rs.* 5 per 100 yards, or *Rs.* 88 per mile. In Messrs. Wilson and Darrah's experiments stone uprights and barbed wire were used, and the cost was 1 rupee per 9 feet (*Rs.* 587 per mile), or as much as *Rs.* 6·6 per acre for enclosing a block of 200 acres extent. Major Wingate, at Mian Mir, Kohat, and other places, has, however, carried out ditching, banking, and hedging at much lower rates than those stated in the Report of Messrs. Wilson and Darrah.

In Messrs. Wilson and Darrah's experiments it was necessary to entirely enclose the land, but in the case of a "fuel and fodder reserve" the entire charge of fencing, &c. might, I think, be replaced by guards (*chowkidars*), at a salary of *Rs.* 2½ per month each.

Exercise of privileges

The privileges of using the "reserves" should be exercised in the way I have indicated before, viz., by the granting of an annual license on payment of a certain yearly sum entitling the holder to timber, firewood, grass, &c., in specified portions of the "reserve," so long as these are required only for domestic use, *but not for sale*; also to grazing (when it can be allowed) for cattle which are the *bonâ fide* property of cultivators.

Control of "reserve."

In the establishing of such blocks, and in advising as to their management and working, the aid of the Forest Department must undoubtedly be sought. Where the blocks are large enough in extent, or numerous enough to warrant it, they should be put under a Forest Officer, or be included in a Forest Circle; but where they are nothing more than village blocks, and far away from "reserved forests," they would not warrant the employment of a special officer, and in this case they should be placed under the Collector, Deputy Commissioner, or other local Revenue authority.

The person who has the actual responsibility should be the village headman, the individual known in different provinces by the various names, *patel, lambardar, monigar, mukaddam,* &c. *Chowkidars* would be employed as the guards in actual charge. As firewood is to be taken out by the people as required, and not sold by the head-load, the need of special forest guards to check the amount would not be experienced.

In many parts which I visited, the desire was expressed by the people that they should be brought, in such matters, in connection with the Collector or similar Revenue official, rather than that they should have "fresh Departments" to control them. Although I am aware how overburdened the Collectors in many cases already are, I cannot see a better way, where blocks are small or scattered, than the plan I have indicated. Above all, there must be no collision of authority. Generally speaking, the Collector is the man who knows best what is adapted to the needs of the district.

Cutting of timber and grass.

It would be necessary to close the blocks entirely at first for a few years, to allow of their establishment, but the object should be, not to grow trees of any large size, but rather to grow sufficient and suitable wood for implements and for building requirements, and mainly quickly-growing trees, such as *babul* (*Acacia arabica*), *jhand* (*Prosopis spicigera*), *dhák* (*Butea frondosa*), and any scrub, brushwood, &c. These should not be allowed to stand a long time, as in a timber-growing forest, but should be cut down as soon as can be done consistently with keeping up a continuous supply. One-fifth or one-tenth might be cut over each year.

The trees once started, grass would rapidly make its appearance too, and I am not at all sure whether the best plan would not be to only allow the grass *to be cut*, but not to admit grazing at all, except in case of severe drought. Goats certainly should not be admitted unless parts can be specially reserved for them. There are many other details into which

I need not enter; such as, whether blocks should be reserved for grazing; whether the whole should be cut in rotation or not, and other points. They are questions for the Forest Department to decide upon.

Village committees.

Government will have to initiate the work.

In some parts it will be possible, as has actually been done in the Central Provinces, to have a village committee or *panchayet* to manage among themselves the internal arrangements, under the control of the Revenue authority, and to this *panchayet* the village headman would be responsible. In the case, too, of villages which might in the future follow the example set and decide to turn their village waste into a "reserve," the working of it through a *panchayet* would be a good plan. In the majority of cases it will, however, be found that the "reserves" will, at first at least, have to be worked practically by Government, and in this matter, as in the kindred instances of tea and cinchona, the Government will have to *initiate* the work, and then they may withdraw.

The financial prospects.

195. As to the financial prospects. Taking, for example, an area of 500 acres; there would be the purchase of the land, say 1 rupee per acre, the cost of planting and maintenance, and, as annual charges, the interest on *Rs.* 500, say at even 6 per cent.,* together with the wages of two guards at *Rs.* 2½ each per month, say *Rs.* 60 per annum. An annual charge of 1 rupee per householder would, in all probability, meet the cost, and, without pressing in any way unduly upon the people, would supply them very cheaply with wood, fuel, and grass.

The financial return not the sole consideration.

But, as I have indicated before, it is not the question of actual return alone that has to be considered. It is also the well-being of the people, and the maintenance of the soil's fertility. In no way can these be better secured, and the Land Revenue to the State be ensured, than by supplying wood to the people as fuel, and thus enabling the cattle-manure to be used on the land. It is not, therefore, a matter which can be judged purely by the direct financial return, but is one the utility of which must be judged by wider considerations, such as, that, if it be neglected, it may imperil the fertility of the soil, the prosperity of the people, and the wealth of the country.

"Relief work."

A good deal of this work may be considered as "protective" in character, and may be carried out as a measure of relief in times of scarcity or famine, and be paid for out of the "famine fund."

Part of the profits of the Forest Department should be used for developing "fuel and fodder reserves."

196. In this connection I would urge the consideration that the profits obtained by the Forest Department should not go, as at present they do, simply to swell the Imperial Revenue, but that a portion of them should be devoted to the work of increasing the supply of wood for *agricultural* purposes. Outlay will certainly be required, if the scheme is to be realised, and it would be only right that a portion of the profits should be set aside for a work having such an important bearing on the welfare of the country at large.

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* This is probably unnecessarily high; 4 per cent. might be sufficient.

CONCLUSIONS.

CONCLUSIONS

197. In so far as the differences which exist between the agricultural conditions and practice of different parts arises from varying facilities for the supply of wood, an improvement in agriculture may be expected to come from a modification of these differences. Such modification can be effected by increasing the supply of wood, more especially of firewood, to those parts which are insufficiently provided with it. The task of doing this is one clearly beyond the reach of the people, and it is to Government that they must look for help. It is possible that in some cases the people will follow, in a small way, the example set them, but the duty is one which Government must take upon themselves, just as they have done that of the supply of water.

The provision of wood as fuel, to take the place of the cow-dung at present so largely burnt because wood is so scarce, is the only practical way to ensure the sufficient manuring of the land, and the keeping up of its fertility. If this be not done the State must be prepared to meet a diminution in the revenue derived from the land, and a decrease in the prosperity of the cultivating classes.

There is no doubt that forests have been destroyed, and that cultivation has been pushed on without sufficient reservation of land for the supply of fuel. The Forest Department, happily, has stepped in to prevent the further destruction which the people, if left uncontrolled, would have continued to carry on. Originally the duties of the Forest Department were non-agricultural, and consisted in the preservation and development of large timber forests. The success was judged from the financial standpoint alone. In later times, however, cultivation has spread nearer to the large forests, and wooded tracts have been reserved among existing cultivation. This has called for a change in the policy of the Department, and its functions have necessarily become more agricultural. Much good work has been done by the Department, but it is still necessary to extend it in a more agricultural direction than before. The "forest reserves" in Ajmere-Merwara afford a good example of what can be done, and of the policy which should be adopted on an extended scale. After reviewing the existing supplies of wood, it is evident that the requirements of agriculture are very insufficiently met, and that the creation of further supplies throughout the country is urgently called for. The establishment of "Fuel and Fodder Reserves" is the most desirable form in which effect can be given to this recommendation. Such "reserves" should be primarily adopted to serve agricultural ends. There is a considerable amount of land which might be taken up for this purpose. In some cases Government waste land is available, in others land must be acquired by purchase. The results must not be gauged by financial considerations alone, but by the benefits conferred on the agricultural population, the keeping up of the soil's fertility, and the maintaining of the Land Revenue to the State. Enquiry is needed in order to ascertain exactly what the requirements of each district are in respect of fuel, &c., and how these may be met. Continued encouragement should be given to the spread of Arboriculture. The Forest Department is certainly undermanned, and the present financial check placed upon its further development in an agricultural direction should be removed.

RECOMMENDATIONS.

RECOMMENDATIONS.

198. I recommend:—

- The creation of fresh "Reserves" of wood, fuel, &c. ("Fuel and Fodder Reserves"), primarily for agricultural purposes.
- The increase of Plantations along canal banks, railway lines, &c.
- The further encouragement of Arboriculture.
- The establishment of Agricultural Enquiry to ascertain the requirements of each cultivating district in the matter of wood supply.
- The setting aside yearly of a portion of the Forest Revenue, to be applied to the extension of "Fuel and Fodder Reserves" to meet agricultural needs.

CHAPTER IX.

GRASS.

Grazing.

Grazing areas in distant forests.

199. THE subject of grass supply is closely connected with that of the foregoing chapter, inasmuch as the forests provide the principal grazing areas, and the "fuel and fodder reserves" afford a certain amount of grass for cutting. Included among the more distant forests are large pasturage areas, the value of which for this purpose has always been recognised, and which, on this account, have never been broken up. To these tracts professional graziers and hereditary castes of cattle-breeders resort, taking with them from the plains the most valuable of the *raiyats'* cattle, for the purpose of seeking shelter and pasture for them during the hot season. The retaining of these areas for the purposes of cattle-breeding is very desirable; it is, however, not the actual cultivators who directly make use of them, but particular castes who make this their special business, and who often bring cattle from a long distance. It is in these grazing areas that the bulk of the native butter called *ghi* is produced.

Grazing in "reserved forests."

200. In addition to the pasturage provided in the open and more distant forests, there is another class, but still distinct from the village "waste" or common land to which I shall refer later. This class comprises the grazing areas belonging, or which till recently did belong, to villages or individuals, but which are now included in the "reserved forests." In the Bombay Presidency (where these areas for the most part occurred) the land was known as *gáirán* or "grazing," *i. e.*, land set apart for grazing cattle. It differs from the "waste" immediately around the villages in being really useful for the purpose, whereas the latter, as a rule, is little more than bare ground. The Forest Department frequently found it necessary to take in these lands when forming their "reserved forests," and in Bombay, according to the new grazing rules of 1890, the term *gáirán* is to cease, and free grazing is to be provided in the open part of the forest for the "agricultural cattle" of villages which have contributed *gáirán* to the formation of a forest block. These areas are let out, and communities often combine for the right of cutting grass in them.

Gáirán in Bombay.

Forest revenue from grazing land.

The Forest Department derives a considerable income from the foregoing grazing lands, and in looking at the Forest Revenue it is well to bear this in mind, and to remember that, whereas formerly the returns derived from forest pasture land were included in the general Land Revenue, they now go to swell the Forest receipts.

Provision of grazing in forests desirable.

201. The provision of grazing in "reserved forests" is at once a desirable and legitimate object by which the interests of cultivators may be served. I would repeat Sir D. Brandis' note, quoted in the last chapter:—

Sir D. Brandis' opinion, 1883.

> "It must now (1883) be distinctly recognised that not only does the "provision of timber and firewood come within the legitimate scope of "Forest administration in India, but one of its most important duties will, "in future, be to increase the supply of cattle fodder, particularly during "seasons of drought in the drier districts."

Madras Resolution, 1890.

Importance of forest grazing in time of drought.

The Madras Resolution of October 1890 concurs in this expression, and affirms that the provision of pasture, small timber, fuel and leaves, is the chief object of the "reserved forests" throughout the greater part of the Madras Presidency (*see* paragraph 175). The importance of the forests in time of drought is very great. The Government of India's Resolution of March 1883 pointed out that even the growing of fodder-crops would not replace grazing land, because, in time of drought (except in the few secured tracts that are thoroughly irrigated), the fodder-crops would fail too. The service done by grazing areas in the famine of 1878–79 has been referred to in paragraph 163. During the last Mysore famine many cattle were lost through the owners having no place where they could feed them. This perishing of the cattle involved not only a direct loss to the cultivators, but also a loss of manure to feed the subsequent crops. Had there been throughout the country such "fuel and fodder reserves" as have been suggested in the last chapter, many valuable cattle would, undoubtedly, have been saved.

Provision of grazing not an *absolute necessity* in ordinary times.

202. But, notwithstanding the benefits which "reserved forests" and "fuel and fodder reserves" may afford in *exceptional* times, I cannot regard the provision of grazing in "reserves" as an *absolute necessity* in *ordinary* times. It is a desirable purpose for the "reserved forests" to serve, if it can be given consistently with other considerations, and in times of drought it may prove invaluable; but I could not assert more than this. In brief, I would say that I consider the provision of fuel to be of the greater importance, and that it would, as a rule, be better to have the grass cut than grazed by stock.

Conditions under which grazing may be permitted.

203. When, without interfering with the general purposes which a "reserve" is to fulfil, grazing can also be permitted, well and good; but it must only be carried on under conditions which do not destroy the main utility of the "reserve."

Exclusion where natural reproduction is going on.

Where natural reproduction of trees is going on, grazing must, for a time at least, be altogether excluded. If land is heavily grazed the soil gets hard, the seed that falls from the trees is eaten or broken, or, if it comes up, the shoots are trampled down. The surface soil is rendered impenetrable to forest seeds, and trees can only be got to grow by means of planting. In a forest where clearing is done by "selection" of trees over the whole area, reproduction is going on continuously, and grazing would always do harm. Often it is the case that the forest cannot be treated in any other way. But where it is possible to work it in blocks, then it may be quite feasible to admit grazing in special blocks at a time. There is, of course, the difficulty of preventing cattle, when admitted, from straying over the whole area. This I noticed to be the case at Etawah (*see* paragraph 181). The people having complained about being shut out from grazing, they were allowed this privilege in one part of the "reserve." However, they abused the concession, and when I visited Etawah I found cattle straying over other parts than those in which grazing was permitted.

The Madras Resolution of October 1890 says on this point:—

> "The working plans for the "fuel and fodder reserves" should contain "proposals for throwing open certain areas to grazing, while keeping "others closed against all heads."

Sir D. Brandis' opinion.

The necessity of restriction was recognised by Sir D. Brandis. He held that during the first few years some restriction in grazing must be entailed in the formation of new "reserves." He said:—

> "At first protection must be absolute, but meantime the grass that "grows up abundantly can be cut, and supply fodder till the forest is "sufficiently advanced to admit of grazing."

Unwillingness of forest officers to provide grazing.

204. Restriction in grazing sometimes arises from the unwillingness of forest officers to provide it; sometimes from the past bad treatment of forest land by the people rendering restriction imperative. On the Shahdara (Lahore) plantation the space for grazing is confined to the portion which is about to be cut over in the then year, or year following. Even to this the forest officers object, saying that grazing makes the soil hard, and prevents the shoots from coming up afterwards, whilst, if the cattle were allowed among the medium-sized trees, they would get at the boughs. I fear that where wood-growing is *the* object there will always be considerable difficulty placed by the forest officials in the way of providing grazing facilities.

Restriction of grazing called for by bad treatment of forests in the past.

At Salem, which used to be a great cattle-breeding district and noted market for stock, I heard great complaints that since the forests had been "reserved" the people could not keep so many cattle, and only had their own fields to feed them on, whereas formerly they had free grazing rights in the "reserves" two miles off. Grazing was still allowed, but it was at a minimum, in consequence of the way in which, by excessive grazing, the "reserves" had been treated in the past.

The number of cattle must be restricted.

205. It is not enough to confine grazing to particular blocks at a time, but the number of cattle admitted must also be limited, for unrestricted grazing is fatal, and is the chief cause of the many bare plains and hill sides that are to be seen in India.

The Government of India's Resolution of March 1st, 1883, pointed out that:—

> "The cultivated area had increased at the expense of the grazing area, " and uncultivated land had been rendered bare and unfertile by unre-" stricted grazing of sheep and goats, causing vegetation and scrub to " disappear, as in Scotland."

Cheviot Hills.

The latter reference is to the Cheviot Hills, which have long been the resort of breeding-flocks of sheep. These flocks have removed a great deal from the soil, and, in particular, phosphate of lime, so that now the hills do not carry the amount of stock that they used to.

Action in Madras.

The Madras Government, in their Resolution of 1890, made provision that the cattle required for agriculture and for domestic purposes should have the first claim on the Government "reserves," and that surplus cattle should only be allowed when circumstances permitted. The grazing rates for agricultural cattle were to be one-half those for others.

Action in Bombay.

"Agricultural cattle."

In the Bombay grazing rules limitations have been imposed on the number of cattle allowed to graze, and the order in which the privilege may be exercised has been determined. This has led to a difficulty as regards the definition of the term "agricultural cattle," inasmuch as, according to the Forest Department's interpretation, milking-cows, buffaloes, and cattle used for transit would be excluded, and only such cattle as are used in the plough, or are worked at wells, would be included. This close definition does not appear to me at all a fair one, and the permission should certainly be extended to all cattle which the cultivator keeps for *bonâ fide* agricultural purposes.

Restriction as to *kind* of stock admitted.

Grazing by goats objectionable.

206. Next, there must be restrictions not only as to the *number* but also as to the *kind* of stock admitted to grazing. Comparing cattle with sheep or goats the former are decidedly preferable, sheep and goats eating much more closely, and doing far more damage to trees and shoots. Goats, there is little question, are highly objectionable animals to have in a forest; the destruction they do to young trees by climbing up and pulling down the branches, and often whole trees, cannot be contested; besides, they eat off the bark and kill the young trees. I quite agree with suggestions made, that goats must either be excluded from forests altogether, or else be only allowed in a special part demarcated for the purpose. The rearing of goats is not one likely to be given up, and where it is an important industry it may be necessary to mark off special areas for their use; but, speaking generally, as their presence in a forest simply means ruin to it, they must be excluded. Both in France and in Germany it has been found necessary to altogether prohibit grazing by goats in forest areas.

According to the Bombay grazing rules, only one goat is let in to graze to every 50 sheep, there being an idea in Bombay that sheep will not graze unless led by a goat. In both the Bengal and the Madras proposals for the formation of "reserves" goats are excluded entirely from grazing, except in areas set aside for them. Camels may be classed with goats as being equally destructive, but sheep graze more than they browse, and are not nearly so bad as goats, for they do not climb up nor tear down the branches of trees.

Other restrictions.

207. Free grazing by cattle should never be permitted if it can be avoided, and the system of payment per head of cattle admitted is very preferable to that by area grazed.

"Close" season.

I can quite understand the necessity of having a "close" season, when grazing is not permitted, though this, unfortunately, may come at the very time that the cattle would find the forests most useful. Thus, in April and May there is great danger of fire, owing to the dry nature of the grass, and people coming in with cattle and kindling a light may easily cause great destruction to the forest. In June and July, again, there is no growth of grass, and to admit stock to the forest then is often to destroy it altogether for the future. Of forest fires I have spoken, and the damage they cause to the future growth, so that, although a temporary growth of grass may come as the result of setting the dry coarse grass on fire, this is obtained only at great loss to the forest (*see* paragraph 164).

Cutting of grass in "reserves" is preferable to grazing.

208. Unless where distant forests are concerned, or where "reserves" are sufficiently large to permit of grazing, I am in favour of grass being cut and removed rather than of its being fed off by stock. At *rukh* Jelleke (near Changa Manga) the people pay 1 rupee for the privilege of cutting and removing one head-load of grass each day during one month. At the Etawah "reserve" the grass is cut by a contractor, and is sold on the spot for ¾ anna per head-load of about 100 lbs.; this is sold at 2 annas in the village, and the price in Cawnpore is 6 annas. The grass is principally *palwa* (*Andropogon pertusus*), a good feeding grass. *Dáḅ* grass (*Eragrostis cynosuroides*), used for thatching, and *baib* grass (*Pollinia eriopoda*), used for making bedding, ropes, and paper, also grow well. The quantity of grass being beyond the requirements of the village, a scheme was set on foot to get hay presses, and to send the pressed hay to Cawnpore. A great deal of the grass is, indeed, wasted. This leads me to remark that in the case of an over-abundance of grass there is no reason why it should not be made into hay and stacked; or, if the weather be wet, the grass may be put green into pits simply dug in the ground, and so be available as silage. Either of these plans would form reserves of fodder which in times of scarcity would be invaluable.

Surplus of grass should be made into hay, or else into silage.

The "village waste."

209. Passing now from forests to the common grazing grounds of villages, the village commons, or, more properly, the village "wastes," I may say at once that I regard these simply as so much standing-room and as "exercise grounds." As for providing any herbage, they are, except perhaps just when the rains come, absolutely useless, and the existence of them is only an invitation to keep so many more half-starved cattle than the land can carry. They are instances of the destruction done by over-grazing; for, no sooner does a blade of grass show itself than it is nibbled off, and the place is soon left bare.

Mr. Sen, writing of Burdwan (Bengal), says:—

> " The system of cattle-grazing—and it is the same all over Bengal—
> " is most wasteful; cattle roam without restriction, the grasses have no
> " opportunity to grow, and it is a struggle for existence between them and
> " the cattle."

Throughout the Deccan the village grazing ground is nothing more than "cattle standing-room." I have frequently examined these "village wastes," and have generally found them to be bare during the cold and the hot seasons, and during the rains to have little more than a covering of *annual weeds*. Such was the case, for example, at Baroda. At Nadiad, where the cattle were well cared for, I found that the cultivators did not use the village common at all. Their cattle were fed with the grass grown as a border round their fields, and on the village common were only the cattle belonging to tradesmen and others in the town, but not those of the cultivators.

Frequently a source of harm.

But there is a more serious side to this matter of the "village waste." Were its influence merely negative, one might stop here, but there is no doubt that these bare open spaces are often productive of positive harm. Not only do they permit of hordes of miserable cattle being kept on them, but the number of the latter is constantly being increased by the offspring of parents, the one as wretched as the other. Religious prejudice prevents the slaughtering of these cattle, and so they drag out their miserable existence until death comes, or disease sweeps them off wholesale. If once the latter appears, it makes short work among animals so little prepared to resist it, and the "village waste" becomes a hotbed of disease, and a *nidus* for spreading it over the country around. The impossibility of segregating affected cattle while these "village wastes" are open is one reason for the enormous loss of cattle by disease which takes place in India.

How to make the village waste useful.

The only way to render these "wastes" useful would be to enclose them and then let only a limited number of cattle in. It would be possible to show the people what effect enclosure, even of a strip, would have; but the village common, as shown in the last chapter, is a difficult matter to interfere with, and, except where the area is more than the village requires, Government could not well step in and take up the land. In some parts, as in Kapurthala (*see* paragraph 178), the people may spontaneously follow the example set them of planting trees, but this must be left to them, although much may be done in giving them encouragement to do so.

Grazing along canal banks and in plantations.

210. Canal banks and plantations afford, in some cases, grazing or a supply of grass for cutting. Along the canal banks near Cawnpore no cattle are allowed, but the grass is cut and removed; between Hurdwar and Rurki grazing is allowed along the canal banks; it is let for from Rs. 20 to Rs. 50 a mile, to the highest bidder, without limit as to the number or kind of cattle. Grazing along the Eastern Jumna Canal is confined to the village that happens to be in the immediate vicinity; as a consequence, there is no competition for it, and the whole grazing along such a strip may be let for as little as 8 annas. The canal banks outside the Changa Manga plantation are leased to the Forest Department; and the latter gives "permits" for grazing for one month at the rate of 4 annas for each cow and 6 annas for each buffalo.

In the Changa Manga plantation itself there is no grazing, it being irrigated by water channels from the canal. In such cases grazing is out of the question. But there is, as I shall show more fully in a later paragraph, a great deal of grass grown in the plantation and in open spaces, which might be utilised either as hay or as silage.

Grass-growing by cultivators.

211. In some parts of the country the people themselves are aware of the advantage of growing grass along the edges of water channels and the borders of fields. This is the case at Hospet (Madras), the people cutting the grass from the canal banks for their cattle. At Ahmedabad I saw grass being cut from the railway banks. On the journey between Rewari and Hissar (Punjab) I frequently noticed grass patches along the sides of fields, and drovers in charge of cattle which were grazing there. But the instance of greatest care in this respect that came under my notice was at Nadiad, in Gujarát (Bombay), where, as I said just now, the cultivators do not use the village common land for their cattle. But every one of their fields is enclosed with a hedge, and then comes a headland of grass from 15 feet to 20 feet wide all round the field, and producing capital grass. This is the more remarkable, inasmuch as the rent of the land is as much as Rs. 5 per acre. There is a double object in this practice, for, as the fields are hedged and have trees round them for supplying firewood and wood for implements, the people know quite well that crops will not grow when thus shaded, but that grass will. They obtain four or five cuttings of grass in the year as food for their cattle, and when the fields are empty the cattle are let in to graze on them. At Baroda the same plan is adopted, but the grass is not of such good quality. I was naturally led to ask why this practice was not followed elsewhere; but, in many cases, for example, on the black soil of Khándesh, the grasses that would grow would not be the fine ones found at Nadiad, but coarse, deep-rooted ones, which would soon spread over the whole land and become a regular pest. Also, where rain, as in Khándesh, is not plentiful, hedges would not grow without irrigation.

Nadiad.

Dúb grass (*Cynodon Dactylon*) in many parts comes up naturally, or may be easily propagated from cuttings simply stuck in the ground. As a crop for irrigation it gives a great yield, and is about the only grass that keeps green in hot weather. To one coming newly to the country it is surprising to notice how, from an apparently burnt-up and dead surface a crop of fresh grass will spring up on the first fall of rain.

The provision of grazing is not coincident with existence of the best cattle.

Instances.

212. There was an old Muhammadan rule which provided that there should be one acre of grazing land to every 10 acres of cultivated, and in the State of Jeypore new settlers still receive 25 acres of grazing in every 100 acres of their occupation. But where cultivation has pressed upon forest and waste land, the area under grass has had to give way. In Nadiad there were formerly 900 acres of grazing for 9,000 acres of cultivated land, but now the former is diminished to 250 acres. I have made many enquiries to ascertain whether cattle are dependent on having grazing or not, and, though it may, undoubtedly, be a great advantage for them to have it, I do not find grounds for regarding its provision as an absolute necessity, nor does it appear that where grazing is the most plentiful the best cattle are always to be found. In Bengal, for example, there is grazing in abundance, but the cattle are poor and small; in Champarun (Behar) there is plenty of grazing, and good grazing too, and yet the cattle are the worst of any in Behar. At Nasick (Bombay) there is no grazing, yet the cattle are splendid; at Máhim, with its heavy rainfall, grass is plentiful, but the cattle are very small, though buffaloes are, by way of contrast, very fine.

Mr. Fuller tells me that in the Central Provinces the worst cattle are found, as a rule, where village grazing is most practised. This is the case in the Chattisgarh division, and generally where there are rice lands. Numbers of cattle die from disease in Chattisgarh. The one exception is the Balaghat division; here the main crop is rice, and there are no village grounds, but the soil is good and all the cattle are stall-fed. Pulse crops are grown along the top of the embankments of the rice fields. In the Punjab generally, there is little grazing at the command of the cultivator, but the cattle, fed as they largely are on fodder-crops, are hardly anywhere to be found better, and are kept all the year round on the holdings, the buffaloes being the only animals that require to be driven to the forests or river sides in the hot weather. In the North-West Provinces and elsewhere, cattle may be seen roaming over the fields after the harvest has been reaped, and subsisting on apparently nothing; but, with what they pick up and the straw-chaff (*bhusa*) which is given to them, they manage to get on, and as soon as the rains commence the fields rapidly become covered with grass.

Will the *raiyat* keep land under pasture?

213. The next question is, Will the growing of grass ever form a part of the *raiyat's* ordinary cultivation? I do not think that it will. Here and there he may be induced to grow grass for the supply of military Stations or camps, but these, especially the latter, are ever liable to be changed. At Belgaum, fields are grown with grass, two cuttings are obtained yearly, and 6 annas is the sum paid for 100 lbs. of green grass. No seed is ever sown, only the grass that comes up naturally being used. In a few parts, such as Kalyan, near Bombay, and Culna, near Calcutta, grass is cut, and hay of an inferior kind is sent to the respective cities; but the *raiyat*, as a rule, looks to his field to supply himself with grain and his cattle with fodder, and I cannot help thinking that he is right. Again, he could only grow a continuous supply of grass by the aid of irrigation, and he is hardly likely to afford this for his cattle alone. He may, and should, grow fodder-crops, but he will not, I think, grow grass. At Salem each cultivator used formerly to have a bit of pasture land which was given at the low assessment of 4 annas an acre. If this system were revived, the cultivators would again grow pasture. In this district, where the sale of cattle is an important one, it might possibly pay, even now, to keep some land down to grass. But the idea of making one part of the land feed the other is foreign to custom. A large proprietor can set land apart for this purpose, but not a *raiyat* with an average holding of 2½ acres or so.

Mr. Nicholson says of Coimbatore:—

> " Occasionally grass is sown for pasture (*hariáli* and *kolei-kattei*); it is kept " down some years and then ploughed up and re-sown, or other crops sown."
>
> " Early in the century all the best lands were under cultivation, and only " inferior ones in grass. Up to the time of the new Settlement (1880) the " tenant used to hold one-fifth of his farm as pasture at one-quarter its " assessment, and only changed to full rates when he turned it into arable " land. This was abolished at the new Settlement."

Where pasture is urgently required, encouragement may be given to its formation by giving remission of assessment, but it is only exceptionally that the cultivator will put land in grass if he can grow another crop on it.

Grass Farms, Haymaking, Silage.

Cantonment Grass Farms and military *rukhs*.

214. I have visited several of the Grass Farms which are under the Military Department, and which are intended to supply grass, hay, &c., for the requirements of the mounted service. My particular object was, to form an opinion as to whether grass could be grown, and either be cut and given green, or be made into hay or silage, so as to render it profitable to the *raiyat* to keep some of his land under grass. The Grass Farms were the only ones from which I could obtain any definite particulars as to what had been done, and I have pleasure in acknowledging the readiness with which full information was given to me by the authorities. In addition to the Cantonment Grass Farms, such as those at Allahabad, Cawnpore, and elsewhere, there are the *rukhs* or uncultivated grass lands devoted to military purposes; these occur largely in the Punjab. The word *rukh* originally meant a *tree*; this shows that these areas originally were *wooded* ones. Now the word is equivalent in meaning to "grass run."

System started in 1882.

215. Without going into descriptions of any of these Farms, I may briefly say that the system of enclosing grass lands for the purpose of supplying fodder to mounted troops was started in 1882 by Sir Herbert Macpherson at Allahabad, and since then has been extended largely, so that now there are two Circles, the Eastern and the Western, under which the different Farms and *rukhs* are included. In the Western Circle, which comprises the greater number of *rukhs*, Major Wingate has been appointed Special Forage Officer, The former "grass-cutter" system.

Previous to the introduction of the Grass Farm system, the practice had been to send out "grass-cutters," whose duty it was to cut and collect grass for the troops from wherever they could. As the grass chiefly came off the cultivators' fields great friction was caused between the *raiyats* and the "grass-cutters," and serious fights often occurred.

In addition to the "grass-cutters" for British mounted corps, one "grass-cutter" was maintained between every two *sowars* or Native Cavalry soldiers, and a pony was kept for him. Pensions had to be provided for the "grass-cutters," and, altogether, their cost might be fairly put at Rs. 5½ a month for each horse kept. In addition, very considerable sums had to be paid to the Native Cavalry as compensation for fodder purchased in order to make up the short supply of grass obtainable by the "grass-cutters."

The cost of hay is reckoned at 8 annas a maund (80 lbs.), and that of feeding a horse, at 2 annas a day, or Rs. 4 a month; besides this, the *sowar* had to feed himself, and along with another *sowar* maintain one "grass-cutter" and a pony between the two of them. If the "grass-cutter" could not get sufficient grass, then fodder had to be purchased. The Government scale of reckoning at Allahabad was that 35 maunds of green grass, or 40 lbs. of silage, were equal to 25 lbs. of hay or 20 lbs. of straw-chaff (*bhusa*). If the monthly cost of the rations exceeded Rs. 13½, then compensation was paid to the Native Cavalry at the Government rate.

Changes effected by the Grass Farm system.

216. Owing to a full supply of grass being now obtainable by the "grass-cutters" from Government grass lands, not only have a large number of the "grass-cutters" of British mounted corps been dispensed with, but the claims for compensation for dearness of forage which used to be paid to the Native Cavalry have lessened very considerably at nearly all the Stations, and have ceased altogether at several of them. In 1889-90, payment of compensation had entirely ceased at six Stations in the Western Circle. Great saving has further been experienced by the reduction in the number of pensions to be paid to "grass-cutters." Thus, not only is there an actual money saving, but troubles with cultivators have been stopped, the horses are believed to be less subject to anthrax (the grass no longer coming from unprotected and suspicious sources), and the Stations have been much improved, the covering of grass having prevented the blowing about of dust. A more healthy state of surroundings is also produced by the growing of grass instead of that of ordinary crops, which latter would in almost all cases have to be irrigated.

The financial result.

217. The result of the operations shows that a very large saving to Government has resulted from conserving the grass lands of Cantonment and military *rukhs*, and the system is one that ought to be extended wherever practicable. Allahabad has, perhaps, been the most conspicuous success, and besides the great credit due to Sir Herbert Macpherson, to Colonel Marriott and other officers who have been successively in charge, special mention should be made of Sergeant Meagher, who has shown much energy and ability in carrying out the practical part of the work. The saving to Government at Allahabad in 1889–90 was estimated at Rs. 25,000, and for the seven years, 1882–89, at Rs. 91,158; in other words, these are the sums which Government would have had to pay had the usual rations of straw-chaff (*bhusa*) been issued to transport and other animals, had full complements of "grass-cutters" been maintained for British mounted corps, and had compensation been paid to the Native Cavalry for fodder purchased to make up the "grass-cutters'" short supply of grass.

The amount of grass grown at several of the Stations, including Allahabad, has been so increased that it is now possible to supply not only the British troops, but also the Native Cavalry with it.

It is, however, with the *actual cost* of the operations of cutting, haymaking, and ensiling that I have mainly to do; though, I should add that, in making any critical remarks, it must be remembered that in most of the Stations the operations are still in their infancy.

The cost of haymaking in India.

218. The great difficulty on the Grass Farms is the employment of sufficient labour, and hence, to anyone with ideas of cheap labour in India, the cost of haymaking, &c., will appear very high for that country. I am also prevented from instituting the full comparison I wished to make, because the profits stated are not the *actual profits* of the Farms by sale of produce in the open market in competition with private enterprise (representing what is actually over and above rent, cultivation, &c.), but the returns are merely comparative, viz., as to what Government *would have had to pay* if the Farms had not existed. So I must content myself with giving a few items and making a few suggestions.

It is generally reckoned in India that from 2¼ to 2¾ tons of green grass will yield 1 ton of hay. At Allahabad the amount is 67 maunds (of 82 lbs.) of grass to 1 ton of hay.

The following table gives the cost of cutting and haymaking, &c., at Allahabad and other Stations:—

TABLE XII. Cost of Cutting Grass and Making Hay at Grass Farms.

———	Per Maund (80 lbs.) of Hay made.	Per Ton of Hay made.	English equivalent, taking the Rupee at 1 *s.* 6 *d.*
Allahabad, 1888–89:	*Annas.*	*Rs.* *a.*	£. *s.* *d.*
Cutting grass, 1 anna per maund - - - - -	2⅓	4 2	– 6 2
Making, stacking, and thatching hay - - - -	⅔	1 2	– 1 8
TOTAL Cost of Haymaking -	3	5 4	– 7 10
Cawnpore, 1890 - - - - ditto - ditto -	4	7 –	– 10 6
Bareilly, 1890 - - - - ditto - ditto -	5	9 –	– 13 6
The Punjab generally, (according to Major Wingate) - - - ditto - ditto -	4	7 –	– 10 6

Rate for cutting grass.

From 1 anna to 1½ annas per maund (80 lbs.) of green grass may be taken as the general rate for cutting.

Comparison with cost of haymaking in England.

219. In the comparison which I shall make I purposely take the Farm where the operations have been longest practised viz., Allahabad; at the same time, the cost here is the lowest.

Unmanured land at Allahabad is reckoned to yield about 48 maunds, or somewhat less than 2 tons, of green grass to the acre, but by using manure (night-soil and town-sweepings, *see* paragraph 143) the yield has been increased from an average of 2 tons of green grass per acre in 1883–84 to one of 5¼ tons, or about 2 tons of hay to the acre over the whole Farm. The extent of the Farm is 3,558 acres in all.

The yield of grass per acre (5¼ tons) is not unlike what ordinary good land would give in England, but this is the average over the whole of the Allahabad Farm, there being only sufficient manure to supply it to portions in turn. Where a heavy dressing of manure is newly put on, as much as six crops of grass can be got in a year, five being cut for feeding green and for silage, and the sixth for hay, while for five years the manured land will keep on producing an average of 22$\frac{1}{7}$th tons of grass per acre yearly.

To compare next the relative costs of cutting grass in India and in England. In England 1 *s.* an acre for cutting by machine, and 2 *s.* 6 *d.* per acre for cutting by hand, are prices frequently met with.

Cutting of grass more expensive in India.

The yield of hay per acre in England is from 1¼ to 1½ tons, as against the 2 tons per acre at Allahabad, so that the cost of cutting would at most be only 2 *s.* a ton in England as against 6 *s.* 2 *d.* in India. A rate of 6 *s.* 2 *d.* per ton of hay, for cutting alone, must be considered enormously high in a country of cheap labour like India, where an agricultural labourer, one may say generally, can live quite happily on 2 annas (or about 2 *d.*) a day.

The total cost of haymaking in England will vary much according to the crop, its weight, &c., but 10 *s.* *an acre* all round, giving from 1¼ to 1½ tons of hay, may be taken as a fair average in the case of grass like that met with in India. This would give a total cost of from 6 *s.* 8 *d.* to 8 *s.* *a ton* of hay, as against the 7 *s.* 10 *d.* per ton at Allahabad.

Haymaking at Grass Farms is too expensive.

We are obliged, therefore, even when taking the most favourable estimates, viz., those of Allahabad, to conclude that, at present, haymaking on Grass Farms in India is a dear process, the expense of cutting being the main cause. Besides, there is not the difficulty and expense of turning the hay which is met with in England, for in India the hay practically makes itself.

The estimated value of hay.

220. When rent and other charges are reckoned, the cost of production of grass at Allahabad is stated to be Rs. 3 As. 10 per ton, and of hay, Rs. 10 (say 15 *s.*) a ton. The grass is estimated to be worth Rs. 7 per ton, and the hay Rs. 20½ (say 31 *s.*). This, it is true, is merely an estimate based on the fact that, if the hay had not been there, it would have had to be replaced by straw-chaff (*bhusa*) bought from contractors at the current rates of grass supplied by ".grass-cutters."

This value is too high.

The estimated value of hay, 31 *s.* per ton, and for such hay, or rather dried grass, as is obtained, is much above the real value, and is very apt to lead to misapprehension, for, if the *raiyat* could get anything like that sum for growing grass and for haying it, he had better lay out his land for it at once wherever sale of hay is possible. A fair value to put on hay in India is from 8 to 10 annas per maund (80 lbs.), which makes it Rs. 14 to Rs. 17 a ton (say 21 *s.* to 26 *s.*).

These estimates, as I have shown, do not enable one to judge whether grass-farming *pays as farming* independently of sale to Government at comparative rather than competitive values. However useful, therefore, Grass Farms have been in the past, and whatever large economies have been effected, there is ample room for great economy still, if the cost of cutting grass and of making hay be considerably more in a country of cheap labour than it is in one of dear labour like England.

Pressing and baling of hay for camps.

221. The experiment has been tried, and at times with success, to press and bale hay for transport to camps. Thus, for the Muridki camp in 1889, grass was cut from two *rukhs* at Mian Mir, and from the forest plantation at Changa Manga. Bales of hay, weighing 60 lbs. each, were made, and altogether 18,500 maunds of hay were delivered in camp, at a cost of 9 annas a maund (80 lbs.), which included 2 annas for carriage. The then price for loose dry grass in the camp was R. 1 As. 4 per maund, and a saving of Rs. 9,000, or over 100 per cent., was thereby effected in the expenses of the camp. Besides this, if there had been less grass, and consequently a greater demand for it, the price current would have gone up, and even a larger saving would have been shown. As regards the hay sent from Changa Manga, the experiment was carried out by the Forest Department, and 5,075 maund of baled hay were forwarded to the Muridki camp. The grass cost 1 anna a maund to cut, and at first 2 annas, then later 3 annas, per maund to make into hay. After baling and all other expenses had been paid, the Forest Department, by receiving from the camp 7 annas a maund for the grass (exclusive of carriage), realised Rs. 2,190 by the sale, and made a profit of 1 anna 3 pies on every maund, or 33 per cent. on the outlay. Not only this, but, after arrival at Muridki, the Commissariat Department, as we have seen, made a saving of over 100 per cent. in the camp expenses under this head.

Experiment at Changa Manga.

The result of the Changa Manga experiment may be summarised thus:—

	Rs.
Cost of 5,075 maunds baled hay, delivered at Muridki, at 10 annas 3 pies per maund -	3,251
Cost of dry grass at Muridki, at price current, 1 rupee 4 annas per maund - - - -	6,344
Saving by the experiment - - Rs.	3,093

When I add that, on account of the difficulty of getting labour, the Forest Department ask now to be relieved from the trouble of continuing the work, and that the Commissariat Department say that they cannot get hired labour to send to cut the grass, it must strike everyone with regret that such an undertaking, yielding 33 per cent. profit to one Department, and effecting a saving of over 100 per cent. to another, should be stopped.

In another case, hay was made on *rukhs* Katlakput and Chandra, near Lahore. Altogether, 1,147 maunds of grass were cut, and the hay was sold at Katlakput without being baled. In all, 952 maunds of hay were sold at 6 annas per maund, and the account stood thus:—

	Rs.
Total cost (including carriage from Chandra to Katlakput) - - - - - - - -	235
Cash received, at 6 annas per maund - -	357
Profit - - -	Rs. 122
	or 51 per cent.

The requirements of camps are, of course, exceptional, and a continuous demand for grass supply may not exist; without this, it is probable that the undertaking might not be a paying one from year's end to year's end.

The objections of the Forest Department to supplying grass for camps.

Nevertheless, Changa Manga might always be used for supplying hay to Quetta, to which Station 2 *lakhs* (2,00,000) of maunds of straw-chaff (*bhusa*) are annually sent from Amritsar. A great saving would be effected if hay were sent instead from Changa Manga. The Forest Department says that its establishment is for forestry and not for grass-cutting, and, while allowing that the result of the Changa Manga experiment was successful financially, the Department says that this was only so because it did the work itself, and, in so doing, left a lot of its forestry work untouched. The work needed a lot of supervision, and would only tempt local labour, this being insufficient for the purpose. It is also stated by the forest officers that the greater part of the grass in the Changa Manga plantation is a coarse grass called *gharam* (*Panicum antidotale*), which the Commissariat will not use, even for litter. When, however, I went to Changa Manga I saw a large amount of *anjan* (*Pennisetum cenchroides*) and of *chhimbar* (*Eleusine flagellifera*), both of which are capital fodder grasses, and might have made good hay or silage.

The labour difficulty.

222. The labour question is indeed a perplexing one; the main reason of the difficulty in procuring it is, that the people will not leave their own fields to come and cut grass, for labour is required just at the time that they want most to attend to their own crops. This is at the end of the rains, when the lands have to be ploughed. Cheap labour, too, is often very inefficient labour, and I have seen with positive annoyance, near Mian Mir, coolies leisurely cutting grass with small sickles, while squatting down on the ground, the sickle in one hand and their pipe (*hookah*) in the other. A cooly gets 1 anna for a bundle of grass weighing not more than 100 lbs., and, having cut that, he generally goes away. It is seldom that a man will stay to cut three bundles a day, and, meantime, thousands of tons of grass are going to waste. The Commissariat Department has to pay even more, viz., 1 anna 3 pies per bundle, the cutting being let out to a contractor. I could not help looking with regret at the great possibilities open, when such quantities of grass, and fair grass too, were waiting to be cut, and would in the end be wasted. The saving that could be effected to the country from this source alone would surprise anyone who looked into the matter. And, while I urge the extension of grass schemes for military purposes, as having proved a distinct saving already, it behoves the authorities to look much more closely into the matter of economy in the charge for labour, and to see if the difficulties cannot be met. I simply throw out a suggestion: why labour is not procurable is, because the work is not continuous; might it not pay to keep up a regular staff to do this work, instead of depending on the occasional cooly who may choose to come and cut his bundle, get his anna, and then go off?

The use of machinery upon Grass Farms.

223. I would make another suggestion. I am quite certain that over large areas, such as many of the Grass Farms and *rukhs* cover, an immense saving might be made by using mowing machines in place of cutting by hand. I am not in favour of introducing "improved" implements except in special cases, but this is one in point. Where ground is very uneven, a machine cannot, of course, be used, but there are many places where, seeing the enormous cost of cutting by hand, and the difficulty of getting labour, a mowing machine would effect great economy.

I have heard some of the Farm Overseers object to mowing machines, and to say that the grass gets knocked down rather than cut. This, however, I believe to be merely due to prejudice. It is true that a machine does not cut so closely as the Native's sickle does, and so the yield of grass will be less. But mowing machines have been tried with success at Mhow (Central India), and an acre of grass land only costs 1½ annas to cut with a machine. A European will cut seven acres a day, a Native from five to six acres, with the machine. To cut an acre of grass by hand costs, on an average, on unmanured land, Rs. 1 As. 13.

I am quite certain that on large areas simple machinery for cutting, tedding, &c., will pay well. Elevators for stacking hay would often be very useful. There is no reason, either, why battery horses should not be used for drawing the mowing machines. Another want is that of a portable press for compressing fodder. Those in use at present are mostly "Boomer" cotton presses, and they are all of them too heavy. What is wanted is to bring the presses readily to where the fodder is.

Silage.

The cost of making silage.

224. Ensiling, or the preserving of green fodder, has been carried out at Allahabad, Cawnpore, Hissar, Mian Mir, and, on an experimental scale, at other military Stations; also on Government Experimental Farms and elsewhere.

From the statistics which I have gathered I have been able to institute a comparison between the cost of haymaking and that of making silage, and the result is decidedly unfavourable to the latter. The loss of weight incurred in the process is surprisingly large, and the cost is so great that it would, in most cases, have been far more profitable to have made hay.

The following table will illustrate this :—

——		Grass ensiled.	Silage produced.	Total Cost.	Cost per Ton of Grass cut.	Cost per Ton of Silage produced.	Per-centage of good Silage.	Loss in ensiling.
		Tons.	*Tons.*	*Rs.*	*Rs. as.*	*Rs. as.*	*Per Cent.*	*Per Cent.*
Allahabad	1888–89	2,187	1,231	5,850	2 11	4 12	56·28	43·72
	1889–90	2,324½	*1,072	–	1 1	–	–	–
Cawnpore	1888–89	560	170	721	1 5	4 4	30·42	69·58
Hissar	1888–89	94	–	606	6 7	–	–	–
	1889–90	–	–	–	3 2	–	–	–

* Estimate.

Comparison with haymaking.

Taking Allahabad in 1888–89, we have the following comparison :—

2,187 tons of grass produced 1,231 tons of silage, costing to make, Rs. 5,850, or 4 rupees 12 annas per ton of silage (as above).

If made into hay (2¾ tons of grass = 1 ton of hay), 2,187 tons of grass would have given 795¼ tons of hay, costing to make, Rs. 4,175, or 5 rupees 4 annas per ton of hay (as per table XII., paragraph 218).

Or, taking the figures of 1889–90 :—

2,324½ tons of grass are estimated to produce 1,072 tons of silage.

2,324½ tons of grass would have produced 940 tons of hay.

The value of hay being, as we have seen before, more than twice that of grass, it is manifest that, whichever year we take, it would have been very much cheaper to have made hay.

The grass has to be cut whether hay or silage be made, and this is the heaviest item in the cost. Owing to the time of year at which grass is cut for silage it costs less than when cut for hay. Thus, grass for silage is often cut at Allahabad for 6 pies (½ anna) a maund, but when cut for hay it will cost 9 pies a maund in September and October, 1 anna in November and early December, and 2 annas afterwards.

Until silage can be made with very much less loss and at much cheaper cost than in the instances given above, it is very certain that it will not be able to compete with hay-making.

225. At Allahabad, silage is valued at 5 maunds (of 80 lbs.) to the rupee, which makes it 5 rupees 9 annas a ton, or, in English equivalent, 8 *s.* 4 *d.*, a figure which, even in England, would be considered high.

Estimated value of silage.

This estimate is based upon the cost of its production, but here, again, the estimate is merely a comparative one, based upon what the Farm would otherwise have had to pay for purchased fodder, so that it gives us little guidance as to whether the ordinary cultivator would be justified or not in making silage.

226. The following are other instances of the making of silage.

Other instances of the making of silage.

Hissar.

At Hissar, where grass can be irrigated, it is cut for silage, as it is found to be too coarse to make into hay.

Mian Mir.

At Mian Mir cutting of grass begins about the middle of August, and goes on to the end of December; there are four silos on *rukh* Terah, in each of which from 800 to 900 maunds of silage are made yearly.

Ootacamund.

I saw very good silage indeed in a silo on the Government Cinchona plantations at Ootacamund. Fifteen and a half tons had been made at a cost of 4 rupees 4 annas a ton; this, it will be noticed, is about the same cost as at Allahabad and Cawnpore. Earth to a depth of 4 feet, and giving a pressure of about 400 lbs. to the square foot, was used to weight the silage, this being, I thought, an unnecessarily large amount; 1 foot depth of earth is quite enough for all purposes.

Beheea.

Messrs. Thomson and Mylne make silage at Beheea, putting the grass into a pit simply dug in the soil.

Belgaum.

At the farm attached to the Agricultural Class at Belgaum there is a silo dug 16 feet deep in the soil, the sides being plastered with dung and well beaten.

Bhadgaon.

Silage has been made for several years past at the Bhadgaon Experimental Farm. The silos are circular masonry pits. At my suggestion a "silage stack" was made by simply building up green fodder, grass, roadside cuttings, &c., just as a haystack would be made, but weighting the whole with stones, or any other inexpensive material that was at hand.

Poona and Nagpur.

At the Poona and Nagpur Experimental Farms silage has been made on a small scale.

227. I can speak very favourably of the quality of the silage produced at the different Farms and Stations mentioned above. Its chief fault is that it is unnecessarily dry. Of course the value depends mainly on the nature of the material used, and rich silage can never be obtained from poor material, although the process of ensilage may render coarse food more palatable.

The quality of Indian silage.

228. One advantage of cutting an early crop of grass for silage is that there are many grasses, such as numerous species of *Panicum,* which seed in the rains: these may be secured as silage if rain continues, whereas the other grasses, being kept back somewhat, yield a good hay crop about October when the rains are over.

The advantages of ensilage.

It may further be said in favour of silage that, by means of it, some grass, which would otherwise have been altogether lost owing to the heavy rain, is saved by being put into the silo.

Improvement possible in methods of making silage.

229. It is, however, when one goes into the figures of the cost of production, and examines the actual loss of weight between the time of putting in the grass and of taking out the silage, that one sees great room for improvement in the methods of making silage in India. I may, therefore, make a few suggestions here.

Suggestions for improvement in the practice.

It is quite true that the real value of the process of ensilage consists in saving what would otherwise be lost, and hence it is not always fair to compare the cost of making silage with that of making hay. This I am ready to allow, but to a very limited extent only, for I have myself seen at Allahabad, Hissar, Mian Mir, and other places, silage being made in large quantities when the weather was, and had been, as fair as possible, and when there was not the least excuse for making silage; indeed, what was going into the pits had been lying about and was really half-made hay already. I would insist strongly that this is a great mistake, and that, as I have endeavoured to show, it is false economy to try and make silage when hay can be made perfectly well.

To allow grass intended for silage to lie about is also wrong. The essential feature of silage is that it is a wet or green food, therefore it should be packed in the silo as quickly as possible, be rammed down close, and covered over rapidly. If it is left about, it may just as well be made into hay at once.

I was reminded, when speaking in India on this point, that, in order to make so-called "sweet" silage, it is necessary to let the grass lie about for several days after being cut, so that it may get partly dry; but my advice to those who are going to make silage is, not to trouble about whether it be "sour" or "sweet" silage, but to get the grass packed away in the silo as quickly as possible, and then shut it up closely, thus avoiding loss, and getting finally as much succulent green fodder as possible for use when all else is dried up.

The great waste incurred in making silage is due partly to loss of moisture before the material goes into the silo, partly to imperfect pressing and the nature of the sides of the pits, and, lastly, to loss in taking out the material. Of the first I have spoken; as to the second, I am convinced that where a silo is to be a regular institution, and is not merely used for an occasional crop, it will pay infinitely better to have it made in brick-work or masonry (*pucca*) than to have a silo with earth sides and bottom (*kutcha*). The extra initial expense will soon be covered by the extra amount of fodder saved. As regards the third point, I have noticed that, on taking out the silage, the usual practice is to remove the whole of the covering at once, and to leave the bulk exposed. This, again, is a great mistake, for the pressure should be continued as long as possible, and the covering over the silage should only be taken off the portion which is actually being cut into for daily use.

Disagreement with views expressed as to India being the great country for silage.

230. I have gone at some length into the silage question because I differ entirely from the opinions of one of my predecessors, to the effect that India is the great field for the development of ensilage. That it is the field for hay-making I am much more ready to think. With a sun and climate such as exist over the greater part of India I cannot see how it could well be otherwise. Hay requires no making, for it makes itself. Silage, I repeat, will only be useful when by means of it can be saved what would otherwise be lost.

The unsuitableness of mechanical appliances for the making of silage.

Still less do I think there is scope for any of the patent appliances advocated for "stack-silage" making. The *raiyat* may possibly be shown how to preserve green fodder, road-side grass, &c., by building it up into a stack and weighting it with stones, timber, or other inexpensive material, but where is he to find the money to purchase such appliances as have been sometimes advocated, and which cost from 12 *l.* to 20 *l.*, and even more? Such mechanical appliances may have a certain value upon large estates possibly, but surely none upon five-acre holdings.

Experimental Farms should conduct trials on the making of silage.

It becomes, however, one of the useful functions which a Government Experimental Farm can fulfil, to conduct careful trials upon different methods of making silage, and to ascertain how it can be made with the least loss, and in the most economical manner. Information may thus be gained as to the crops best adapted for ensiling, and as to the adaptability of the process to the *raiyat's* circumstances.

Suggestions for improvement in the management of Grass Farms.

231. There are some points in connection with the management of Grass Farms wherein improvement can be effected. The Station Farms are worked mostly by Grass Committees, of which the President and Secretary are the principal members, while a general supervision is exercised by the Commissary General of the Circle, aided by his Special Forage Officer, the Quartermaster General in India being referred to in all matters requiring the orders or approval of the Commander-in-Chief.

Grass Committees.

I cannot commend the Grass-Committee system. With President and Secretary constantly changing, it is most discouraging for a Forage Officer to work. No sooner does a President or a Secretary get to know a little of the system at one place, than, as a rule, he is transferred to quite different work, and a totally new and inexperienced man is put in his place. At Umballa the Secretary has changed six times within 18 months, and at Mian Mir the President about as often. This cannot mean either economy or efficiency. If, instead of Grass Committees, there were a special Forage Branch of the Commissariat, the difficulties would be greatly lessened.

Farm overseers.

In the next place, the overseers of the Farms are non-commissioned officers, temporarily withdrawn from their corps.

But they are not properly selected, and care is not taken to choose the men who, from their previous acquaintance with the work, or from any aptitude shown for it, are the best fitted for the post of overseer.

At one *rukh* which I visited I found a farm overseer, with the very best intentions, making silage out of grass that had been lying about for several days. The sun was then, and had been, pouring down with intense heat all the time, but the order had gone forth to make so many tons of silage, and he was doing his best to comply with it. I asked him (though I felt the question was needless) whether he had ever made silage before; no, he had "never heard of the stuff before, "until the order came." He was the station butcher! Such a man is to be pitied rather than blamed, but it does seem wrong that, where the field for economy is so large, it should not be better aimed at.

The frequent changes in management.

Another ground I have for complaint is, that when capable men have been selected, or after they have acquired some experience, their services are not retained at the work in which they have shown aptitude. A farm overseer, if he keeps to his work beyond a certain period, does so at the risk of losing promotion. He should be a permanent non-commissioned officer of the Commissariat Department, "seconded"* in the departmental list, so that he may not lose promotion.

This is, I fear, a fault of the entire Indian system, and is, thus, one hard to alter; but, in the interests of the country, I would strongly urge the desirability of retaining the services of men for work in which they have shown special capabilities. Sergeant Meagher, of Allahabad, is such a man as this, and, knowing the energy he has displayed in the practical discharge of his duties, it would be a pity were his knowledge to be lost to this branch of the Commissariat, or he himself lose promotion by remaining where he is. The saving which the Military Department might effect in matters of this kind alone would go a long way towards providing the funds required for the other "agricultural improvements" which I am recommending in this Report.

CONCLUSIONS.

CONCLUSIONS.

232. There are differences in agricultural conditions and practice which result from the greater facilities for grazing and grass supply provided in one part of the country than in another. Improvement may come from a modification of the differences through supplying these facilities where they are most needed.

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* This term means that an officer while employed on work outside his legitimate sphere, would still retain his departmental position, and share in any promotion, reverting, at the expiry of his outside duty, to his position in his Department.

Little is to be expected from the people; the most they are likely to do is, in a few cases, to follow an example set, and possibly to convert the "village waste," or a portion of it, into a "reserve" for the provision of grazing and supply of grass. But the work will practically fall entirely to the share of Government.

In taking up this work, Government will have to avail itself not only of a knowledge of indigenous practices, but also of Western science, as shown in economical methods of hay-making, silage-making, and the use of machinery, such as mowers, hay-tedders, presses, &c.

The provision of grazing by means of the pasturage areas in the more distant forests is very desirable, especially for the purposes of cattle-breeding. Similarly, where "reserved forests" and plantations nearer cultivation can afford grazing without detriment to the other interests which they are called on to serve, the provision of grazing in them is a legitimate and very serviceable end for forest officials to keep in view. In times of drought all classes of forests and woods may prove invaluable to the saving of cattle, and they should then be thrown open.

Inasmuch, however, as in ordinary times the supply of grazing cannot be regarded as an absolute necessity, and since the existence of it is not necessarily coincident with the occurrence of the best cattle, it should be restricted by proper rules as to the area to be thrown open at a time, the time of year when allowed, the number of stock admitted, and also the kind of stock. Where natural reproduction of trees is going on, grazing must be excluded, and goats should only be allowed if separate areas can be given to them. The enforcement of rules as to forest fires is absolutely necessary. In "Fuel and Fodder Reserves" it will be generally found better to allow cutting and removal of the grass than to admit grazing.

The "village waste" is almost always useless for grazing purposes, and often tends greatly to the spread of disease.

It is only exceptionally that the *raiyat* will be induced to keep land in pasture.

Grass Farms have done a great deal of good, and have effected considerable economies by reducing the number of "grass-cutters" attached to mounted troops, by preventing troubles with cultivators, and by saving large sums that used to be paid as compensation for scarcity of fodder. At the same time, it is clear that haymaking, as carried out on these Farms, is much too expensively done, and great economies are possible in the saving of labour by having a permanent staff, and by the employment of machinery. The management of Station Grass Farms by Grass Committees is not good, and the whole should be worked by a special Forage Branch of the Commissariat. The officers in charge of the Farms, as also the overseers, should be selected with more regard to their aptitude for the work, and, when they have shown themselves capable men, should be retained at it, without running any risk of losing promotion thereby.

The Forest Department should co-operate more than it has done in providing grazing and grass for agricultural purposes, and in utilising the grass from plantations, &c., by means of pressing and baling hay, for military purposes.

Ensilage is at present an expensive process in India, and great improvement in the methods employed is possible. There are certain advantages in adopting the process in particular cases, but it will not become a general one in a country like India.

RECOMMENDATIONS.

RECOMMENDATIONS.

233. I recommend:—

The creation of more "Fuel and Fodder Reserves," in order to supply Grass for agricultural purposes, and also Grazing where it can be permitted under proper restrictions.

The extension of Grass Farms, and their management by a special Forage Branch of the Commissariat.

The carrying out of investigations at Government Experimental Farms on the best methods of making Silage.

CHAPTER X.

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FODDER-CROPS AND HEDGES.

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Fodder-Crops.

Fodder-crops.

234. IN the last chapter I came to the general conclusion that the provision of grass, and of grazing in particular, while highly desirable, could not be called absolutely essential.

Fodder-crops not essential to *existence* of cattle.

Nearly the same must be said of the growing of special fodder-crops. Undoubtedly, great advantages follow the giving of these to cattle; the cultivation of them, at least where cattle are appreciated and cared for, should be encouraged, and the endeavour be made to extend the system to parts where it is not practised.

More particularly is this desirable where the provision of grazing is very limited, and possibly entirely absent. Nevertheless, after enquiring into the matter with some care, I have not received more than the general reply that, while cattle are undoubtedly far better for green food of some kind, yet they can live quite well on dry food alone.

This coincides with my own experience in England.

Experiment at Woburn, England.

In an experiment which I carried out at the Woburn Experimental Farm a few years back, I found that bullocks, when fed on cake, meal, and hay, along with water supplied to them separately, but receiving no succulent food whatever, such as roots or grass, throve perfectly well, although the result of the feeding with hay did not prove to be an economical one.

Experience at Bhadgaon (Bombay).

At the Bhadgaon Experimental Farm (Bombay) experience has shown that cattle will do quite well on dry food during the hot weather, provided that they have a little cotton seed given to them.

Mr. Sabapathi Mudliar's experience at Bellary.

Mr. A. Sabapathi Mudliar, of Bellary, told me that he liked to give fodder-crops to cattle if he could, but that they would do quite well on dry food. For cattle in hard work, or for transit bullocks, he did not think green food so desirable. In time of famine, however, he had found the latter invaluable.

At other places also I heard the same opinion expressed, viz., that fodder-crops were not so suited to *working* cattle. At the military Grass Farms there is a similar objection to the giving of silage to animals from which speed is required.

Experience at Grass Farms.

Fodder-crops necessary for *improvement* of cattle.

235. It is one thing, however, to speak of a food not being essential for the *existence* of cattle, but quite a different thing to speak of it being necessary for the *improvement* of cattle. This is where, I believe, the growing of fodder-crops will be required.

It is true, as pointed out in the last chapter, that the existence of pasturage is not always coincident with that of the best cattle, but yet instances were adduced where, as at Nadiad, Baroda, Hospet, &c., the feeding of cattle with green grass from the headlands of fields, the banks of watercourses, &c., was pursued with manifest advantage.

This exemplified: 1. In the Punjab.

The Punjab supplies the best instances of similar advantages derived from fodder-crops. In this Province the people depend greatly on their cattle, and they take proportionate care of them. The district of Jhang is an especially good example, several kinds of crops being here grown entirely for the use of cattle. The Punjab cattle are, as the result, exceptionally fine.

2. In Behar.

The same is seen in Behar, when the cattle of the European planters are compared with those belonging to the native cultivators. The former are fed with sugar-cane, *juár* (*Sorghum*), oats, &c., as fodder, while the latter only have what grass they can pick up, supplemented by straw-chaff (*bhusa*).

The following quotations exemplify this still further :—

3. In Kurnool.

Mr. Benson, in his Kurnool (Madras) Report, says :—

> “ In the Cumbun and Markapur *taluks*, where the soils are generally poor
> “ and thin, Nellore cattle can rarely reach a live-weight of 700 to 800 lbs.
> “ In the Nandyal valley, on rich black cotton-soil, the same breed fed on
> “ the *juár* (*Sorghum*) straw develop to 1,000 to 1,200 lbs.”

4. In Coimbatore.

Mr. Nicholson, in his “ Manual of Coimbatore,” writes :—

> “ Kangyam cattle are famous in Dharapuram *taluk* because of the extent
> “ and quality of the pastures. . . . . The *raiyats* are dependent on pastures
> “ and fodder-crops for the food of their cattle during the hot weather,
> “ and the hedges, acacias, and wild shrubs give a good deal of good fodder,
> “ fuel, and common timber. . . . . Fodder-crops are grown for Kangyam
> “ cattle, *cholum* or *kambu* being sown thickly in garden land in February,
> “ irrigated and cut before earing.”

Principal crops used as fodder-crops.

236. The crops most largely used as fodder-crops are *juár* (*Sorghum vulgare*), known also as *chari* when grown for fodder, and in S. India as *cholum*; *bájra* (*Pennisetum typhoideum*), also called *chambu* in Madras; thirdly, and mainly in S. India, *rági* (*Eleusine Coracana*).

Thick seeding of fodder-crops.

The main differences between growing a crop for fodder and the same seed for a grain crop consist in the thicker seeding and the earlier cutting in the former case. Whilst, for example, 5 to 6 lbs. of *juár* seed to the acre suffice for the grain crop, as much as 120 lbs. of seed per acre are used for the fodder-crop. Fodder *juár* is sometimes fed green, and sometimes stacked when dry.

Juár, bájra, rági.

Over the Punjab generally, fodder-crops are grown for cattle, and *juár*, or *chari*, as it is there termed, is the usual one.

In Behar, *juár* is largely cultivated as a fodder-crop. When young it is believed to be poisonous, and is put round the borders of fields to keep the cattle from trespassing on to the crops.

This crop is also grown in Gujarát (Bombay), at Poona, and other parts of Bombay. At Belgaum it is a frequent sight to see the fodder *juár* growing on the embankments of the rice fields; and dotted here and there over the fields may be seen single plants of *juár* which are cut for fodder.

Bájra, in many instances, takes the place of *juár*, but is considered inferior to the latter as fodder.

In Madras, *rági* mostly takes the place of *juár*, though the latter, there known as *cholum*, is also grown, as well as *bájra* (*chambu*). The straw of *rági* is considered to be the most nutritious of all, and that of both *juár* and *bájra* to be superior to rice straw. *Rági* is used both as green fodder and also in the dry state.

Sugar-cane.

Sugar-cane (*Saccharum officinarum*), as a fodder-crop, is used principally by the European planters in Behar. Like *chari*, it is sown thickly. It is chopped up when green, and is mixed with dry fodder, such as oat straw, &c. This makes a very good mixture for cattle.

Maize.

Maize (*Zea Mays*), called in the Punjab *makki*, is extensively used as fodder in the Punjab, and also in Behar and elsewhere.

Oats, barley, wheat.

Oats, barley, and even wheat are grown for fodder, the two former principally by European planters or on Government Stud Farms. Oats are either cut green and chopped up as fresh fodder, or are allowed to ripen and are used as straw food. Oats and barley are taken by the indigo planters as change crops for indigo.

In the Punjab, wheat is by no means infrequently fed off in its early stages; this strengthens the subsequent crop, and prevents it from being beaten down by wind and storms.

Gram.

Gram (*Cicer arietinum*) is grazed over in the Punjab when still young. In the Balaghat district of the Central Provinces pulses are grown along the tops of the embankments of rice fields, and are used for cattle.

Turnips.

Turnips are largely grown in parts of the Punjab as a fodder-crop. This is the case in the Jhang, Gujranwala, Montgomery, and Multan districts.

Rape.

Rape is another crop similarly used in the Punjab.

Lucerne.

Lucerne, where irrigation is available, is one of the most valuable fodder-crops, especially as green-stuff for horses. Not only can several cuttings (often five or six) be taken during the year, but the plant will last three or four years before requiring to be ploughed up and resown.

Lucerne is always grown and extensively used at Government Stud and Cattle Farms, such as Saharanpur, Hapur, and Hissar, as also at Poona and other Experimental Farms.

Guinea grass.

Sorgho.

Next, I would mention two crops which, though tried experimentally with considerable success, have not yet come into general use. The first is "Guinea grass" (*Panicum jumentorum*), and the second, the variety of *Sorghum saccharatum* known as *Sorgho*. I saw both these crops growing at several of the Experimental Farms, and at the Seebpore Farm, Calcutta. There is a ready demand for *Sorgho* in Calcutta by men who keep milking-cows. It can be cut three times in the year.

Prickly pear.

Prickly pear (*Opuntia vulgare*) has been successfully used as food for cattle, and as (unfortunately for agriculture) it i only too abundant in Southern India, the utilisation of it in time of scarcity would be most desirable. The thorns with which it is covered are an obstacle to its use, but this difficulty has been overcome by Mr. A. Sabapathi Mudliar, at Bellary. On this gentleman's Estate I saw prickly pear being largely used as green food for bullocks. Women were employed to remove the thorns from the shoots after they had been cut and brought in. This they do, holding firmly the pieces of prickly pear with one hand by means of pincers roughly made out of scrap-iron bent into the requisite shape, then, grasping with the other hand a pair of tongs, also made out of scrap-iron and with saucer-like ends, they seize the thorns with the tongs and pluck them out. The pieces are then handed to another woman who cuts them into slices on a knife fixed vertically on a board, the latter being held steady by the woman's foot. A woman, receiving 2 annas daily wage, will remove the thorns from, and cut into slices ready for feeding, as much as 120 lbs. of prickly pear in a day.

Utilised by Mr. Sabapathi Mudliar at Bellary.

Its value in time of scarcity.

Mr. Sabapathi Mudliar has had experience of the value of this fodder, for, during the famine of 1877, quite 75 per cent. of his cattle were kept alive by means of it, they having nothing more to eat than the prickly pear and 1 lb. a head daily of rice straw.

Eight years ago, when Mr. Sabapathi Mudliar became Chairman of the Municipality, he introduced this plan of feeding the municipal cattle, and now they are fed regularly on the prickly pear, and the cost is only Rs. 4 to Rs. 5 a month per pair of bullocks.

Mr. Sabapathi Mudliar is now trying to cultivate a thornless kind of prickly pear.

Need for extended use of fodder-crops.

237. I now give some instances showing the necessity there is for extension of the system of growing fodder-crops.

Bareilly.

Mr. Moens, writing of Bareilly (N. W. P.), says, in an extract already quoted :—

> “There are two points on which our agriculturists need instruction :— “(1) growing green-crops for cattle ; (2) the proper management of their “manure.”

Chota Nagpur.

In Chota Nagpur, fodder-crops are insufficiently known, for of Lohardaga Mr. Basu says :—

> “Cattle are small owing to insufficiency of food. . . . . There is too “little straw in the country, not enough to give more than 2 lbs. per head “to working cattle daily, and this is only rice straw. . . . . There are no “fodder-crops.”

and of Palamau he says :—

> “There is an insufficiency of stored fodder, but it is relieved by grazing “in jungle wastes. . . . . A lot of cattle are bred in the south and west “parts in the forests.”

[illegible]mbatore.

Mr. Nicholson says of Coimbatore :—

> “Fodder-crops are rare ; *cholum* or *kambu* is sometimes grown as a “fodder-crop on ‘garden’ land, but none ever on ‘dry’ land. The “*raiyat* prefers to grow *cholum* to maturity, and get the grain, and so “double the yield. Besides, it saves irrigation from wells.”

At Avenashi (Coimbatore) I found that no fodder-crops were grown specially for cattle. In the rains the "dry" land quickly gets covered with a coating of grass, and this feeds the cattle.

Trees as fodder.

238. Trees are frequently very valuable as supplying fodder for cattle. Among the hill tribes many trees are so used, but in the plains there are also trees that serve this purpose well. The *babul* (*Acacia arabica*) is one of these. Its pods are capital food for sheep and goats, and the shoots and leaves are also eaten by cattle. Other trees and shrubs so utilised are the *Mahua* (*Bassia latifolia*), different species of *Dalbergia* and *Terminalia*, the *Jack-fruit* tree (*Artocarpus integrifolia*), different species of *Zizyphus*, &c.

Little is known of comparative feeding values of Indian fodders.

Dr. Van Geyzel's analyses.

239. Little is known as to the relative nutritive values of different fodders in India. Dr. Van Geyzel, Chemical Examiner, Madras, has made analyses of South Indian fodders with the object of seeing whether they throw any light on the general preference given to some kinds over others, notably to *cholum* and *rági*, as against rice straw, and also for ascertaining how Indian fodders compare with English and American fodders. The investigation is not, to my mind, at all complete or satisfactory; the variations between different samples, though collected from the same district, are far too great to allow of any real conclusion being drawn. Thus, rice straw from Madura gave, in one case, 6·2 per cent. of albuminoids, and in another only 3·5 per cent.; while rice straw from Tanjore contained only ·87 per cent. of albuminoids. The amounts of woody fibre are made to vary from 20 per cent. in one sample to 32¾ per cent. in another; the ash in samples of *rági* straw from Salem varies from 8·2 per cent. to 14 per cent. Many other instances I might give, all showing how much depends on the time at which these samples are harvested, the circumstances under which they are grown, &c. The relative out-turns per acre are not given, and without this there is little to go upon, for what is really wanted is to know the total *amount of constituents per acre*, and which fodder supplies the most and the best of these, as well as whether one sample is individually richer than another, independently of the yield per acre. As I know from experience, analyses of isolated samples taken at random will give little real knowledge, and the whole subject of food-value of straws and grasses is a very difficult one. But this instance shows well the need that there is of investigation, not from the purely *analytical* side, but from that of *agricultural* chemistry specially.

Need of agricultural chemist.

Hedges.

HEDGES.

Their use as supplying fuel and saving manure.

240. In close connection with fodder-crops comes the subject of hedging and enclosing fields. Attention has been directed to the way in which, by affording a certain amount of fuel, live hedges may help to increase the supply of manure to the land.

Use in preventing cattle-trespass.

Again, they are very useful in preventing cattle-trespass and destruction of crops. Hedges are found over the greater part of Coimbatore, and Mr. Nicholson, writing of this, says :—

> "Cattle-trespass is rare; cattle and crops are protected, boundaries "respected, large quantities of fuel supplied, and protection is given to "growing trees."

Mr. W. R. Robertson (late of Madras) mentions, in a Report on Bellary, that hedges of thorn would do much good there by affording similar protection.

In Anantapur (Madras) fencing is unknown.

Their occurrence.

It is in the Madras Presidency that hedges and enclosing of fields are mostly found. I met with them generally in the Avenashi, Erode, Madura, and Salem districts, also at Hospet. But they occur in other parts of India also; for instance, I saw them at Máhim (Thána), Nadiad (Gujarát), Baroda, Ahmedabad, Jeypore, Ulwar, and also at Hoshiarpur in the Punjab. The special way in which, at Nadiad, the hedges and grass borders to the fields are utilised has been mentioned in the last chapter (*see* paragraph 211).

Materials used for fencing fields.

241. As materials for enclosing fields, mud walls are used in the Ulwar State, prickly pear at Jeypore and many parts of Madras, cactus hedges at Hoshiarpur, *euphorbia* hedges around Ahmedabad, as well as generally in Madras, and aloe bushes in Mysore. One of the most useful hedging materials is the *mullu-kiluvei* (*Balsamodendron Berryi*), a thorn which is largely used in Coimbatore and parts of Salem and Madura. It is easily propagated by cuttings.

Mr. Nicholson, speaking of the advantage of hedging fields, gives the following proverb :—

> "Note the field that is hedged, and the cattle that are pastured." Or, to put it in another form: "Compare the cattle that are penned and the "cattle that are (merely) grazed."

meaning that the condition of the penned cattle is far superior.

Where hedges are not grown it is not infrequently the case that a few rows of a special crop, such as linseed, hemp, or *chari* (*Sorghum vulgare*) are put round a field in order to protect the main crop. Cattle, for example, will not eat the linseed bordering a wheat crop; hemp is poisonous, and *chari* in its young state is also injurious to cattle.

Hedge material as fodder.

242. Lastly, there is a certain amount of value to be derived from hedges themselves as food for cattle. Mr. Nicholson points this out in extracts already given in this chapter, and there is little doubt that in time of scarcity hedge material would supply, as was found in the case of prickly pear at Bellary, a useful store of fodder.

CONCLUSIONS.

CONCLUSIONS.

243. In so far as differences in agricultural practice are the outcome of attention being paid, in the better districts, to the growing of fodder-crops for cattle, and of enclosing fields with hedges, while in other parts these are neglected, it will be possible to effect improvement in agriculture by modifying these differences.

It may not be possible to grow hedges everywhere, but the system is one undoubtedly capable of much extension; so also is that of growing fodder-crops, both being followed with much benefit. We have here to deal with the third class of differences alluded to in Chapter II., viz., those arising, not from purely external sources, but directly from a want of knowledge. The remedy must be sought, not in any direct measures which Government can introduce, but in the gradual adoption of the better practice by the people. Government, however, and Agricultural Departments in particular, can aid greatly in the extension of agricultural knowledge, and in the transference of the practice of more advanced districts to those which are more backward.

Fodder-crops, we have seen in this chapter, are necessary for the improvement of cattle, and in times of scarcity such materials as hedge-clippings, prickly pear, and trees, will be found immensely valuable.

But little is known as to the comparative values of different Indian fodders, and there is a considerable amount of work in this direction which can only be done with the aid of an Agricultural Chemist.

RECOMMENDATIONS.

RECOMMENDATIONS.

244. I recommend:—

The extension, wherever practicable, of the systems of growing Fodder-crops, and of Hedging or otherwise enclosing fields, more especially in parts where no pasturage exists, or where it is very scarce.

The employment of an Agricultural Chemist for India, to investigate, among other matters, the comparative values of different Indian Fodders.

CHAPTER XI.

LIVE STOCK AND DAIRYING.

CHAPTER XI.

LIVE STOCK AND DAIRYING.

245. THE subject which we now proceed to discuss is one on which there is not much to be learnt from the ordinary cultivator and his methods, and, in attempting improvement, the experience of Western practice will have to be drawn upon largely.

I have already spoken of cattle as affected by climate, by the existence of grazing, and the provision of fodder-crops. Their importance as supplying the main source of manure to the land has also been fully dealt with.

On points connected with the breeding of cattle I am not qualified to enter, and hence my remarks must be of a very general character.

Improvement of cattle only possible within limits.

246. Inasmuch as both climate and soil largely influence the breeding of cattle, more especially in respect of their size, it is clear that, while improvement of the smaller and inferior breeds is possible, it is nevertheless only so within certain limits.

The Bengali will maintain that his cattle, though small, are strong for their size, and that bigger ones would mean more grain for them and more cost to keep. In the Punjab, on the contrary, the bullocks are large and fine; they are well fed and carefully tended.

The food of cattle.

247. Cattle represent the *raiyat's* capital; they provide the labour in ploughing and other field operations, they are used for drawing water from wells, and they supply manure for the crops. In return for this, all that they get, in many parts, is the grass they can pick off the fields and roadsides during the rains, the stubble left after harvest, and the broken straw (*bhusa*) of cereal crops.

In other parts, as, for example, in the Punjab, they are well cared for, and are fed with special fodder-crops, with green grass, oil-cakes, &c., or else they are driven out to pasturage and shelter during the hot months.

The principal oil-seeds given to cattle as food were fully treated of in Chapter VII., paragraph 127. These are *til* seed, safflower, cotton seed, earth-nut, and linseed. In addition, gram and *dál* (*Cajanus indicus*) are often given.

Excellent cattle may be found in India.

248. It must be allowed that there are excellent cattle to be found in the country, for, in going through it as I did, or in visiting Agricultural Shows, one may see as good cattle as can be desired. I was greatly struck with the appearance of many of the cattle exhibited at the Saharanpur and Meerut Shows, and no one can fail to be impressed with the general excellence of the bullocks used for transit purposes, as also of those employed in military service.

The trotting cattle and driving bullocks that one meets with in Mysore, Rájputana, and elsewhere, are singularly hardy and strong.

But, though individuals may be able to rear fine cattle and to keep up special breeds, this is something quite apart from the improvement of the cattle of the country generally, the cattle of the *raiyat*.

249. The reason why better agricultural cattle are not more generally found is mainly because of the inattention paid to the matter of breeding and selection. Further, the superstition that exists against the killing of bad cattle militates against the herds being better than they are. Still, it is not everywhere that breeding and selection of cattle are neglected. In the Bombay Presidency the Gavlis, or milkmen, follow a system in breeding their cattle; it is mentioned in Reports of the Bombay Agricultural Department that in some villages of the Presidency the people are known to purchase stud bulls at their joint expense. In Gujarát a great deal of attention is given to cattle, judicious crossing is studied, and calves are cared for; oil-seeds as well as fodder are given to the cattle. A bullock will work here for 10 years at a well, or for 15 years if not put to well work.

Breeding and selection of cattle.

Where practised.

In the Southern Mahratta country, cattle are, as a rule, good. Nellore cattle are famous throughout the Madras Presidency, and in certain other parts. The bulls are quite big at two years old, and cost Rs. 150 to Rs. 200 a pair. Nellore cows are greatly prized also. Alambadi cattle are held in high esteem in the Salem district. The bulls cost from Rs. 150 to Rs. 250 a pair. The Administration Report of the Central Provinces for 1887–8 says:—"in most districts "the bullocks used for agricultural purposes are of very "good quality."

The Punjab owes, in large measure, the existence of its fine cattle to the bulls sent from the Hissar Cattle Farm.

From Palamau (Bengal) it is reported that the cattle have been improved by half-bred Behar bulls.

Bhagalpur cows are in demand all over Bengal; the bullocks are used too, but are said to eat 2½ times as much as indigenous cattle. The Amrit Mahal (Mysore) herd was broken up in 1885, but a certain number of breeding cattle are kept by the Mysore Government at Hosúr. The Bhadgaon (Bombay) herd took its origin from this.

Though the above instances can be given, it is very generally the case that the breeding of cattle is left almost entirely to chance, and that no selection is exercised. It has been pointed out in Chapter IX., paragraph 209, how largely the blame for this attaches to the "village waste," where herds of miserable cattle mix indiscriminately together.

Generally neglected.

In many parts of India the young bulls are the only sires of the young stock. They run among the herds until they are four years old, when they are castrated and turned into bullocks for plough or draught work. In this way the young bulls often become sires before they are physically fit to get good stock. After they are turned three years old they probably make fair sires, and the strongest animals do the most duty. Still, it is a not uncommon sight to see an old bullock driving away a young bull from a cow, with the result that the latter may lose an entire season through not being served.

The Brahmani bull.

250. The old Hindu system of breeding is carried on by means of the sacred bulls, or "Brahmani" bulls, as they are generally termed. These bulls, dedicated to Siva or some other deity, are let loose when still young, on the occasion of funeral ceremonies, or in fulfilment of a vow. They are picked cattle, and, being sacred, are allowed to roam wherever they please, no one being permitted to kill them. The custom is still maintained, and in some parts there are too many Brahmani bulls. Sometimes considerable dissension exists regarding the bulls, and frequent troubles between Hindus and Muhammadans arise on this account. In many parts, however, the Brahmani bull is quite extinct, this being due chiefly to the decrease in free pasturage area, and to the decline of faith in the old religious beliefs.

The Brahmani bull, where he exists, is almost always a fine creature, fed on the best of everything. All that a cultivator may do is to drive the bull off his own field, though it may be only for it to go on to his neighbour's. So well does the Brahmani bull fare that it is frequently asserted against him that he gets too fat and lazy to pursue his proper calling, and that the cows get served by the half-starved bulls of their own herds instead. Nevertheless, it is very certain that were it not for the Brahmani bull many villages would be very badly off.

In some parts, however, Behar for example, the bulls are too numerous, and cause serious damage to the crops of the indigo planters. Though they do not eat the indigo shrub itself, they tread it down while searching for the grass that grows under its shade, but nowhere else. Much expense has, accordingly, been incurred by the planters in putting ditches and hedges around their indigo fields.

When the bulls get too many in number, Municipalities often seize them, and work them in the town carts. This proceeding, so long as the bulls are not killed or sold, is quietly acquiesced in.

In the North-West Provinces considerable trouble has been caused by the depredations of cattle stealers and Muhammadan butchers. Muhammadans, being meat-eaters, have not the same sacred feeling towards the Brahmani bull as the Hindus have, and the complaint of the latter is loud that numbers of these cattle are stolen for the purpose of being slaughtered, and that their flesh is sold.

Thus, I heard at Bharwari that the value of a bull had risen from Rs. 10 to Rs. 25 in consequence of the demand for its flesh. Near Cawnpore I heard complaints that there were no Brahmani bulls left, and that the cultivators have to go to the nearest man who has a bull, of whatever kind it may happen to be. The agitation has, more recently, been increased by a decision given by Mr. Justice Straight, in which he declared the Brahmani bull to be "no one's property," inasmuch as it could not be said to belong to any particular owner. The bull is thereby deprived of the protection of ownership, and becomes more than ever the prey of the cattle-stealers and butchers, while the villagers are deprived of the means of getting their cows served. Surely, such a decision cannot be allowed to stand. That men should be allowed to steal and realise money by the sale of the flesh of stolen animals, and then escape punishment on the ground that the animals are "no one's property," seems manifestly unjust, and, in the interests of the agricultural communities, the practice should not be permitted to continue.

Legal decision as to ownership of Brahmani bull

251. It is very certain that without good bulls no improvement in the cattle of the country can take place. Where Brahmani bulls exist in sufficiency there is no need of doing more; but where they are extinct, or where good country bulls do not exist, then Government can do much good by the distribution of good stud bulls.

Distribution of stud bulls to villages by Government.

As I shall presently show, much benefit has been derived in the Punjab from the distribution of bulls from the Hissar Cattle Farm. The same good might be done by the Government supplying other parts of the country, just as it has done in the Punjab. The privilege, when given, does not appear to have been abused. A bull located in a village or town should be under the charge of the village headman (the *patel, lambardar*, or similar official), and the latter should be required to report periodically to the local authority. Further, it should be the duty of the Provincial Director of Agriculture to keep himself informed as to what is being done in each district to which bulls have been distributed. I do not think that any trouble need be taken about the food of the bulls. If good bulls are given, the people will see that they are fed, and the responsibility on the village headman will suffice. The system adopted at Hissar, by which the cultivators can go to the Farm and choose exactly what suits their requirements, is decidedly the best one, and should be encouraged.

It is needless to say that the result to Government cannot be a directly paying one, but it is one which should be undertaken in the interests of the people as agricultural classes.

252. It is well, perhaps, that I should here interpose a remark to show that, when I speak of improving the cattle by using better sires, I am not at all in favour of trying to improve Indian cattle by crossing them with English bulls. The main object in India is to produce cattle suited for *work*, and not,

Selection of native cattle preferable to foreign sires.

as in England, to produce either meat or milk. At th Bhadgaon Farm I saw a bullock that was a cross between a Mysore cow and a Shorthorn bull, a big, beefy animal, that ate a great deal, but was not adapted to ploughing.

Again, it is not enough, nor yet always the best way, to bring in fresh sires; attention must be paid also to the *selection*, for breeding purposes, of the best cattle of a district.

Cattle-breeding Farms necessary.

253. The distribution of stud bulls for agricultural purposes involves the retention of Hissar or other cattle-breeding Farms, and the location of bulls at Government Farms or other suitable places.

I am inclined to think that the good which has already been done by Government in this direction is apt to be overlooked. I had the opportunity of inspecting both the Hissar Cattle Farm in the Punjab and the Bhadgaon herd at the Farm of the Bombay Government, and without, as I have said, presuming to speak too definitely on points outside my particular sphere, I must say that I was much struck, not only with the excellence of the cattle at these Farms, but, what is more to the point, by the impress which they had left upon the cattle of the surrounding country through which I was then touring.

Hissar Cattle Farm.

254. The Hissar Cattle Farm, at the time of my visit and for some years previously, had been under the able management of Captain Marrett. It covers 67 square miles in all, and has about 7,000 head of cattle on it, these being divided into herds according to the different breeds and ages. It was started as long ago as 1813, the primary object being to supply cattle to the army for artillery purposes; a secondary one was to supply agricultural bulls for the Punjab and North-West Provinces. The artillery cattle are variously bred, according as they are required for "pole cattle" or for "leaders," or for other special purposes. The Gujarát cross and the Nagore cross are mostly used as "pole cattle," and the Mysore cross as "leaders."

About 350 head are supplied yearly to the Commissariat Department.

In addition, from 70 to 80 bulls are sold annually for agricultural purposes at the Government price of Rs. 150 each. Intending purchasers are allowed to go to the Farm and to choose the bulls for themselves.

On a farm of such extent there is almost unlimited grazing ground, but the grass is, seemingly, very poor and thin. It is only on spots where the water lodges that enough grass grows to afford a cutting. There is a further difficulty, that of procuring water, for the water-level is so low that wells, if made, would have to be over 100 feet deep. Captain Marrett's efforts to supply green fodder in the form of lucerne, *juár* (*Sorghum*), &c., are frustrated by the irregular supply of canal water, the Farm being situated at the very termination of the canal, and what water there is to spare goes first to the native proprietors (*zemindars*).

Notwithstanding these drawbacks, the Farm appeared to me to be capitally managed, and the stock bred on it were unquestionably fine. What struck me especially was the really splendid condition of the young stock. The calves were left alone in the yards during the day, but had their mothers with them at night; the latter were not stall-fed at all during the rains, but simply grazed throughout the day; and the fact that they were able to support themselves and their calves too, is a proof of how much the grass, unpromising as it looked, could do for them. All the cattle seemed to me excellent and in capital condition, and the spot must evidently be one well suited for breeding purposes.

Of the suitability of the Hissar cattle as transport and artillery bullocks I cannot speak, but I have no doubt of the *agricultural* good that is being done by the Farm.

Impress made on cattle of surrounding districts.

Hissar was the first stopping-place in my Punjab tour, and as I went afterwards to other districts I made a point of particularly observing the cattle. I may briefly say that almost wherever I went in the Punjab I found that the existence of good cattle could be directly traced to the presence of an Hissar bull in the neighbourhood. Thus, at Ferozpore and at Gújrat (Punjab) the ordinary cattle were excellent, and in each case I came across fine Hissar bulls, roaming over the fields, just as the Brahmani bulls do. These bulls, I found on enquiry, had been given *gratis* by Government, but the boon had been appreciated by the people, for they are very fond of cattle. A pair of working bullocks at Ferozpore will cost from Rs. 80 to Rs. 100. In further support of what I noticed myself, I give the following extracts from the Punjab Administration Report for 1888-89:—

> *Karnal.*—"There were six Hissar bulls in the district at the end of the "year; in 1888-89 ten more were got and ten more were applied for, as the "demand was keen and increasing. Practical farmers are deputed to "Hissar to select for themselves."
>
> *Hoshiarpur.*—"There are 24 Hissar bulls in the district, which are "effecting an improvement in the local breed. The *zemindars* highly "appreciate them; they are no expense; they are turned loose in the "town."
>
> *Rawal Pindi.*—"There are 14 Hissar bulls in the district."

The following is from Major Massy's Report of the Kapurthala State for 1889-90:—

> "Hissar bulls are regularly imported. Fifteen Hissar bulls were distri-"buted among the *tahsils*, and were highly appreciated. . . . The young "stock are very promising."

Major Massy adds:—

> "It is notorious that animals of this class were never possessed before by "the Kapurthala peasantry."

I also find that in 1887 two Hissar bulls were sent as far as Arrah (Behar) for use on the Government Estates there.

Bhadgaon Farm.

255. On two different occasions I visited the Bhadgaon Farm of the Bombay Government. Cattle-breeding has been established here for about 11 years, the herd having taken its origin from the Amrit Mahal herd of the Mysore Government, since dispersed. The main object of this part of the Farm is to breed Mysore bulls for crossing with and improving the cattle of the country around. Here, as at Hissar, I could not but recognise that stock were being reared which were very greatly superior to those found in the country generally, and which could not fail to improve the latter if the right steps were taken to distribute the benefit. But it was not that the stock at the Farm alone were good, for, as I passed through the district, I saw evidence of the impress which the Mysore cattle reared at the Farm had made upon some of the other cattle, and how superior to the ordinary cattle were those which had the Mysore "touch" in them. The people of the district have now come to appreciate this, and there is an eager demand for any young bulls that are for sale. In 1889 nine young bulls, two to three years old, were sold at an average of Rs. 58 each. The young stock I saw at the Farm were also most promising. A short time after my visit, viz., in October 1890, 27 young bulls, varying in age from six months to 18 months, were sold at an average of Rs. 40 each for breeding purposes. By this sale alone, Rs. 1,080 were realised, whereas in the Farm Report issued previous to the sale these same animals had been valued at Rs. 650 only. I regard this as a strong proof that the people of the country will before long come to appreciate any source from which good cattle can be procured. The maintenance of the Farm as a breeding-farm for cattle is very desirable, and it is to this purpose that, I think, it is admirably suited; more so, indeed, than as an Experimental Farm in the stricter sense.

Influence on cattle of district.

Satisfactory sales.

Results must not be judged from financial standpoint alone.

256. I have said that the result of distributing stud bulls from these centres cannot be a directly paying one; in many cases, indeed, it may at first be necessary to provide the bulls free to villages. But the work of breeding good bulls, and of improving the cattle, must not be judged from the financial standpoint alone, but from that of the good effect produced in the country generally.

Government Farms should have stud bulls located at them.

257. Where conditions are suitable, and where localities require it, I am distinctly in favour of Government Farms being made breeding-farms for the supply of good bulls for agricultural purposes. Where conditions are not suitable for breeding, but where good sires are wanted, stud bulls might be located at Government Farms. This is done, for instance, at the Saidapet Farm, Madras. If stud bulls were located at the Cawnpore Farm it would, to some extent, remedy the deficiency already referred to in the matter of good bulls.

Also Court of Wards' Estates.

Court of Wards' Estates, again, would be very suitable places at which to locate bulls. It is not, however, enough to merely place the bulls at these Farms, but personal energy on the part of Directors of Agriculture will have to be shown in getting the people to avail themselves of the benefits offered. When this is once done, the people will not fail, before long, to appreciate the result, and to make use of it in the future.

Improvement required in the system of management of cattle-breeding Farms.

258. I cannot pass from this part of the subject without applying to cattle-breeding Farms under the Military Department remarks very similar to those which I applied to the military Grass Farms and *rukhs*. I refer to the evils of the system by which an officer in charge of such a Farm is limited in his tenure of the appointment to a term of five years. The management and breeding of stock require special skill and technical knowledge. It is not *every*, or *any*, man who is naturally a judge or breeder of stock, or who can ever become one. When, then, a man has been found who *does* understand these matters, and who likes the work, and shows ability in its discharge, it seems very false economy to remove him just at the time that he has got the Farm into good working order, and is in a position to effect considerable saving in its management as the result of the experience he has gained. But what too often happens is, that, just at this time, his tenure of office expires, and he is replaced by a novice who may quickly undo all the good and throw away all the work of the past through inexperience. A breeding stud is much more easily spoiled than it is formed.

It is very desirable, therefore, that the men who are to hold in future the position of Superintendents should be those who have shown some aptitude for the work, and they should receive beforehand the practical training, under the Superintendent, for which the Farm provides the opportunity. It would also seem desirable to attach an officer of the Commissariat Department from time to time to the Farm, in view of his acquiring, under the teaching of the Superintendent, that knowledge of cattle and of farming operations generally, which all Commissariat officers should more or less possess.

Plough cattle.

259. Bullocks are the general cattle used for field operations and for drawing water from wells. Bulls as well as bullocks are, in some parts, used in the field. The cow, as being a sacred animal, is only rarely worked, and only by Muhammadans. This is the case at Serajgunge (Eastern Bengal), the Muhammadans regularly using cows for ploughing, but the Hindus not. The same reverence is not always extended to the she-buffalo as to the cow. At Belgaum, when the buffalo cows do not calve, they are sent to the plough or to work the wells.

Buffaloes.

260. In some regions of heavy rainfall, such as Máhim, Igátpuri, and other parts of the Western Ghâts of Bombay, as well as in districts of Eastern Bengal, the bullocks are small and weak. Buffaloes, on the other hand, revel in a wet climate, and are the principal plough cattle; indeed, the ploughing of the rice fields could hardly be carried out without them, for it is literally ploughing in mud covered over with several inches of water.

But where these wet climatic conditions do not exist, the he-buffalo is generally reckoned a misfortune. I saw he-buffaloes being used for ploughing on the Nadiad Experimental Farm, though this is not done elsewhere in the district. Going about the country as I did, and noticing buffalo cows in abundance, and only here and there a buffalo bull or bullock, I was often led to enquire what becomes of the young bull calves.

In Gujarát (Bombay) the he-calf is simply starved off by withholding milk from him. In other parts, he is driven away to the forests to become the prey of wild beasts. In Bengal he is often tied up in the forest and left, without food, either to starve or to be devoured. And yet the people who do this are those who would not allow an animal to be killed outright even if it were in extreme suffering!

Taccavi advances for cattle.

261. The system of Government advances, known as *taccavi*, has been discussed in Chapter VI., paragraph 107: these advances may be made for the purchase of plough cattle as well as for the digging of wells, &c.

There are, I believe, objections to giving advances for the buying of cattle, inasmuch as the purchase represents so much capital which may in turn be parted with, and which is not, like a well, a *fixture* on the land. However, in cases where the cattle of a district have been swept off by disease, and when the cultivator has no cattle left with which to plough his lands or water his crops, the facility for re-stocking his holding must come as a very decided boon.

Dairying.

Yield and quality of milk from Indian dairy cattle.

262. As a dairy animal the she-buffalo is more esteemed than the cow; it yields a larger and richer supply of milk, and is generally better cared for. In parts of the Punjab the purchase of a buffalo is the first indication of prosperity. The two most striking features in Indian dairying are, the small yield of milk given by the cows, and the richness of the milk of the buffalo.

In Bengal the ordinary country cow will not give more than 2 lbs. of milk a day. In Madras it may yield from 2 to 4 lbs. a day. As a rule, the cows will only milk for six months, and often have only one calf in the course of two years.

The milk of the buffalo, on the other hand, is very much richer than average cow's milk in England, for, whereas the latter may be said to contain 3 to 4 per cent. of butter-fat, and 12 to 13 per cent. of total solids, buffalo's milk has no less than 7¾ per cent. of butter-fat and 18 per cent. of total solids.

The yield of milk will, of course, depend upon the breed of the cattle, the food given them, and the care bestowed upon them. The Gujarát, Sind, and Nellore cows are specially noted for their milking properties, qualities in which the Mysore breed, for instance, are deficient. The cattle of these special breeds are, however, very different to the ordinary country cattle.

Throughout Chota Nagpur the village cows are very poor, owing to insufficiency of food and want of fodder-crops; no oilcake or other additional food is given to them. From 1 lb. to 1½ lbs. of milk a day is all that they yield, and their value is from Rs. 7 to Rs. 10 each. Buffaloes, however, cost here Rs. 25 each, and will yield about 5 lbs. of milk per diem. Oilcake is fed to them in the dry season. At Serajgunge, in Eastern Bengal, 2 lbs. of milk is the average daily supply of a cow. In Dacca, cows are rather better cared for, and oilcake is given to them as well as to buffaloes. They will yield, in consequence, about 4 lbs. of milk a day.

In Gujarát (Bombay) milking-cattle are much more valued. Thus, a cow will milk for seven months, giving 5 to 10 lbs. of milk a day, and will cost from Rs. 20 to Rs. 50. The buffalo is still more prized, and, being fed with oilcake, cotton seed, *juár* fodder, &c., will keep in milk for eight months, giving, for the first three months 20 lbs., the next three 12 lbs., and the last two 6 lbs. of milk daily. Its value is from Rs. 30 to Rs. 100.

Nellore cows are good milkers. Some that I saw at the Saidapet (Madras) Farm gave about 20 lbs. of milk a day. They were being fed on 5 lbs. per head daily of earth-nut cake and bran, with *cholum* fodder.

Improvement of milking-cattle.

263. When such differences exist as are instanced above, it is very clear that in many parts improvement in the milking-cattle is possible. As regards buffaloes, the people seem to appreciate their value, and there is little, I think, that need be done further. But there is a good deal that may be done towards improving cows, more particularly where the sale of milk or the manufacture of the native butter, called *ghi*, is carried on. This will be found to be chiefly the case where pasture and grazing areas abound, and where the professional graziers resort with the cattle of the villagers, generally taking payment themselves in a share of the milk. Beyond where such pasturage exists, little is done to maintain the cow specially as a milking animal; but the buffalo takes its place, and the cow is looked on rather as the breeder of future plough cattle. Thus, while the distribution of stud bulls for breeding working-cattle is capable of wide extension, it will, I think, only be in special parts, and where pasturage exists in abundance, that improvement of the milking strains of the country cattle will be effected to any great extent.

This matter has, however, not been altogether neglected at Government Farms, for, at Hissar, Mysore cattle are crossed with Sind, Gujarát, Angole, and Nagore breeds, partly with the object of improving their milking properties, the Mysore breed being specially deficient in these. At the Bhadgaon

Farm, Malvi cows are kept as nurse cows for the young Mysore stock; and at Poona, investigations have for some time been carried on as to the milk-producing qualities of Gujarát and Aden cows, and on the influence of different foods upon the yield of milk.

Dairy Farming in India.

Mr. H. A. Howman's visit in 1889.

Native method of making *ghi*.

264. Of late, efforts have been made to extend the practice of Dairy Farming in India. Mr. Ozanne, who, at the time of my visit, was Director of the Department of Land Records and Agriculture in the Bombay Presidency, was foremost in the endeavours to foster this industry. A considerable impetus was given to the movement by the visit to India, in 1889, of Mr. H. A. Howman, a well-known dairy-farmer, from Warwickshire, England, and who came out on behalf of the Dairy Supply Company, Limited, of London, for the purpose of introducing the mechanical "Cream-separators," for which that company were agents. These separators were of Swedish make, the invention of Dr. de Laval, and were of a size which could be worked by hand-power. Mr. Howman also took over with him a number of other appliances for making butter. The native way of making butter is, to boil the milk as soon as drawn from the cow, then to cool it, and, after adding a little sour milk, to let it stand from 12 to 20 hours in a brass vessel narrowed towards the top. After standing, the milk is churned by the rapid twisting round in it of a stick which is kept spinning round by the hand, first warm and then cold water being added now and again, but quite empirically. The butter "comes" in about a quarter of an hour, and is strained off on to a cloth, the sour butter-milk, called *tâk* or *chás*, being much relished by the people. The butter is collected, put into another brass vessel, and melted over a fire. This operation requires careful watching, and good *ghi* makers are adepts at it. In the heating, the water is evaporated, and a portion of the mass, which is probably the enclosed curd, deposits at the bottom of the vessel, the remainder being poured into jars and stored. This is the *ghi*, or native butter, so largely used in cooking, &c., and it has the property, which ordinary butter has not, of keeping good for a long time.

Mr. Howman's experience.

Mr. Howman, when he first came to India, was met with what proved to be a difficulty,—the exceptional richness of buffalo milk. But this was soon overcome, and wherever the mechanical separators were shown at work, the opinion was universal that capital butter was produced, and that the system which Mr. Howman demonstrated, that of making butter without it being at any stage touched by the hand, was an immense improvement on, and a far more cleanly method than, the native one. The butter which Mr. Howman made would also keep quite well for a week. He further showed that he could not only make *ghi* from the butter produced, but that from the separated milk the sweetmeats and curds, in which the Native delights, could be made perfectly well. The separation also gave, in the form of freshly-separated milk, a perfectly sweet and wholesome article of drink. In England the main difficulty with the cream-separator has been the utilisation of the skim-milk, and this is likely to prove the same in India. If the Natives show a readiness to take it, either for drinking or for manufacture into sweetmeats, this obstacle may be overcome, but not otherwise. It was, however, when Mr. Howman put himself into competition with the skilled *ghi* makers that he failed in showing that he could produce more *ghi* than the native manipulator. He could always get more butter, but in making it into *ghi* the Native excelled. I cannot, however, regard the trials as by any means satisfactory or complete. In one butter-making trial which I witnessed, the native operator showed himself very clever in making up his butter with a great deal of water, so that it might weigh heavy, whereas Mr. Howman's butter contained no superfluous amount. Then, when Mr. Howman's butter was made into *ghi* this was done by the *ghi* makers, and it is very certain that in some cases, at least, it was spoilt by them. But the chief consideration is the following. In the absence of any chemical investigation into the nature and composition of *ghi*, it is impossible to say what *ghi* exactly is, and whether, as made by the Native, it is purely butter-fat, or whether it does not contain some amount of curd. The latter, indeed, is probably the case. The butter, as made by Mr. Howman, was merely butter-fat, without curd; this may account for the fact that Mr. Howman obtained more butter but less *ghi*. What is really wanted is the investigation of such points as these by an agricultural chemist resident in India itself.

Need of an agricultural chemist.

Mr. Howman's visit undoubtedly showed that great improvement was possible in dairy matters in India, but whether the benefit will extend beyond the European community is questionable.

Steps taken to follow up Mr. Howman's teaching.

265. Mr. Ozanne was not slow to follow up the stimulus given to the plans he had had for some time in contemplation. Mr. Keventer, a Swiss, who had assisted Mr. Howman, was retained in India by the Bombay Government, and the Agricultural Department started a Working Dairy in the city of Bombay. This was fitted with cream-separators, churns, refrigerators, &c., and so successful was the sale of butter, that, after a time, the concern was taken over by a private capitalist and worked by him. Then another capitalist started a second similar business, and, at the time I left, both were succeeding well. At Poona, also, butter is similarly made by the Agricultural Department, and is sold in the town. Mr. Keventer was lent for a time to the North-West Government, and at Cawnpore and elsewhere he showed the process of butter-making. He was also engaged in demonstrating that cheese might be manufactured in India. The berries of *Puneria,* it may be mentioned, can be used in India for the purpose of curdling milk; they are obtained from Sind.

At the Saidapet Farm (Madras) a cream-separator is used. There is a ready sale for cream, and more is sold as such than as made into butter. The students of the college (Natives) do not care for butter, so I was informed.

Is there likelihood that improved dairying methods will spread in India?

266. This leads me to the consideration whether butter-making by improved methods is likely to make much advance in India. I must say I hardly think that it will, so far as the native population is concerned. Butter will not replace *ghi*, for the reason that it will not keep anything like the time that *ghi* does. The Native, again, makes *ghi* with the simple utensils he has at hand; he could not make butter in this way. But, wherever there is a considerable European population, then, I think, English dairying may be pursued with much benefit and comfort to the community. I could not help wondering how, in such towns as Calcutta, Bombay, Madras, Poona, Allahabad, and others, the English residents put up with the so-called "butter" with which they are supplied.

Unsatisfactory condition of the milk supply in India.

267. But of greater importance than butter-making is the question of the milk supply; of the conditions under which it is generally carried on the less said the better. The surroundings in almost all cases are most insanitary; the manure heaps are too often close beside the wells and drain into them; the vessels are washed in this water; and the cattle drink it or other equally bad water. Seeing, as we know only too well in England, how readily disease is propagated through the medium of milk, the wonder is that, in India, epidemics have not been more closely traced to impure water, or to insanitary surroundings affecting the milk supply. The supply of milk to military cantonments is one affecting vitally the health of our troops in India, and that this should go on, as at present, without any control, is highly prejudicial to their welfare. There is little or no check upon either the state of the places where the milk is produced, nor upon the adulteration (often with impure water) which constantly goes on. Bombay and Poona are exceptions to this statement, as careful supervision is exercised there.

Wherever troops are stationed, the supply of milk should be carried out by regular contract, and the sheds where the cattle are kept and the milk is produced should be under constant inspection and control by sanitary officers.

Dairy Farms.

268. Schemes for the establishment of regular Dairy Farms in connection with the supply of milk to troops have been suggested by Colonel Marriott, of Allahabad, and others, and I regard the proposals very favourably. Where troops are regularly quartered such Farms might with advantage be established, and should have a herd of good milking cows, with two or three stud bulls. In addition to the milk supplied, the cows would produce calves, which, if females, would be the future milking animals, and if males, would do for entering into Government service as transport and artillery bullocks.

The attention of the Commissariat Department should be strongly directed to this important matter of a pure milk supply to troops.

In addition to military cantonments, Jails are institutions which would benefit from a regular and supervised system of milk supply.

Madura Farm.

At Madura, what was formerly the Experimental Farm of the Agricultural Society is now kept up as a Dairy Farm. There are about 15 cows here, most of them good country cows, and a few Aden cattle. They are reckoned to give about 12 lbs. of milk each daily, when in full milk, and are fed with earth-nut cake and gingelly cake. Milk is sold to the town, but not cream, butter, or *ghi*. This part of the Farm pays very well, and would seem to show that a good milk supply would be appreciated in native towns as well as where Europeans are in considerable numbers. Mr. Ozanne has in prospect the establishment of a large Dairy Farm for supplying Poona with milk, butter, &c.

Horses.

269. Horses do not in India come under the term "agricultural live stock;" but, inasmuch as the Horse-breeding Operations of the Government of India are included under the work of the Agricultural Department, a passing reference should be made.

Horse-breeding Operations of Government of India.

The object of the Horse-breeding Operations is, primarily, to supply Remounts for the Cavalry. Formerly there were army studs at Hapur and elsewhere, but these are now given up, and the Cavalry have been supplied with horses imported from Australia and New Zealand. The endeavour of the Horse-breeding Department has been to improve the horses of the country by mating the country-bred mares with pure-bred sires. The selected sires are either Norfolk Trotters or thoroughbreds, imported from England, besides a few Arabs.

At the different Fairs and Shows, country mares are chosen by the officers of the Department, and are branded as being eligible to be served by a stallion belonging to the Department. Their produce are intended to supply the remounts. The stallions are quartered in different parts of the country.

I went over the Hapur Farm, near Meerut, and saw the stallions of the Horse-breeding Department, and also the breeding mares, and the young stock belonging to the Army Remount Department. It is found necessary to buy the produce of Government sires at as early an age as one year, for, if left till older, the horses are found to be mostly injured permanently. Also at Bhadgaon, Lahore, Gújrat (Punjab), Hoshiarpur, and Salem, I saw stallions of the Horse-breeding Department that were quartered there. In addition to the horses, there were, both at Hapur and at the other depôts, donkey stallions kept for mule-breeding purposes. In the

Punjab and North-West Provinces these were very popular, but in Bombay the idea has not taken at all.

In the Rawal Pindi district (Punjab) alone, there are 25 horse stallions, and 47 donkey stallions, belonging to Government.

In the Central Provinces, Government stallions are located, but are not much used, trotting bullocks being generally used for transit purposes.

It would be travelling beyond my sphere were I to pass any detailed criticism on the way in which the Horse-breeding Operations are conducted. I can, at most, mention my general impressions of what I saw, without wishing to attach much importance to them. But, after seeing Norfolk Trotters in England, I cannot say that I was favourably struck with the representatives of the breed that had been sent out to India; they appeared to be too heavy, too large-bodied for their legs, to have a lack of style and a coarseness of leg which did not bring back to my mind the specimens I had seen in England. It is, I believe, questionable whether the Norfolk Trotter is the right kind of horse to cross with the country mares in order to produce a *cavalry* Remount; the appearance of the young stock would indicate their suitableness for dragging guns rather than for making riding horses.

In the case of the thoroughbreds, the acquiring of a good animal seems to have been sacrificed to the obtaining of a high-sounding pedigree. Of a number of horses that I saw at Hapur, the majority were rather "weedy-looking," and several were lame. But the money difficulty comes in here, and when, as is the case, the purchase price is restricted to 250 guineas, or 300 guineas at the outside, one can hardly expect to get a really good sire.

The Arab stallions were, as a rule, very good, occasionally a little light; the best I saw was one named "Ajeel," then standing at Hoshiarpur.

Some of the donkey stallions were also good. The general fault with them was, that they showed a shrinking of the hoof.

Sheep and goats.

270. Of other farm live stock I need say but little.

Attempts have been made by Colonel Coussmaker and others to improve the breeds of sheep, and to obtain a better wool, but nothing of a lasting or general nature has been accomplished.

At the Saidapet Farm a fresh cross-breed, called the "Saidapet breed," has been established. At the Hissar Farm Jeypore sheep have been crossed with the progeny of Leicester tups and Bikanir ewes. It is stated that the sheep now give wool, rather than the hair which they produced before.

The country sheep (Bikanir) have also been crossed with Australian Southdowns, but the latter only lived six months. Their produce, however, seemed to show an improvement in wool, the price realised for it off the farm being Rs. 25 per maund, whereas the general price for country wool is only Rs. 17.

The question of improving sheep and goats is partly one of providing for them a more abundant supply of food, and not leaving them to pick up merely what they may chance to find. But it is probable, also, that much can be done by careful selection of the stock already in the country, rather than by importation of breeds from other lands.

Cattle Disease.

Cattle Disease.

271. Comparatively little is known in India on the subject of cattle disease, and yet it is one of great agricultural importance, for, when an epidemic breaks out, the cattle perish in thousands, and do not seem to have a power of resisting it equal to that possessed by English cattle. The Natives believe that cattle epidemics are visitations of the goddess "Mata," and that they can only get rid of the epidemic by propitiating the goddess. The variety of names by which diseases are known to the Natives in different parts makes it hard to ascertain how far they really recognise the particular ones and the respective symptoms. To a certain extent it appears that the people are aware of the advantages of isolation, and make some use of it. The herding together of a lot of miserable half-starved cattle on the "village waste" is, as I have previously remarked, one of the most potent means of spreading disease.

In the Central Provinces, enquiries were lately made as to the means of checking the spread of disease, and the replies received indicated that the people would welcome Government interference to prevent the cattle of villages where disease existed, from mixing with those of other villages. But the proposed isolation of individual cattle in a village hospital pound was not so readily approved, and it was felt that the owners would want to go and feed their cattle, and thus would themselves be the means of spreading infection. Yet another difficulty is that of preventing the spread of disease through the sale of hides. When cattle die the *Chamars* or leather-dressers come at once and skin the animals, taking the hide for sale. The hide is their perquisite. It would seem that the only way of remedying the evil arising from this source is to give compensation for the hides destroyed.

Mr. Nicholson, in describing the state of Anantapur, says that *lakhs* of rupees are annually lost by cattle disease. He points out that fencing is not done here, and that segregation would prevent much loss.

Efforts made to cope with cattle epidemics.

272. Within recent years efforts have been made to gain a knowledge of the diseases of cattle, and of their treatment.

At Lahore (Punjab) a Veterinary College was established in 1882, and now has 90 students. A dispensary and hospital

Dispensaries.

are attached to it. At Poona (Bombay) College there is a veterinary course, and men who have passed through it are qualified to take charge of the local dispensaries which have now been started at Ahmedabad, Nadiad, and other towns in the Bombay Presidency. These dispensaries are used to some extent by the different municipalities for the treatment of their working cattle, and their wider usefulness is beginning to be appreciated. In the Punjab also, there are similar dispensaries, and in the Central Provinces veterinary hospital assistants are sent out to different districts to treat the cattle in them.

Bacteriological Laboratory at Poona.

The most important step which has of late been taken is the appointment of Dr. Lingard, a man of established scientific reputation, as Imperial Bacteriologist to the Government of India. Dr. Lingard, after considerable European experience under men of such note as Drs. Koch and Klein, was brought out to India in 1890, and located at Poona, a special laboratory being established for him there by the Government of India, for the express purpose of enabling him to pursue original research and investigate the causes and cure of cattle diseases in India. This appointment is one of great importance, and is almost the first in which a man trained in scientific investigation has been brought to India and enabled to follow original research. Associated with Dr. Lingard is a selected veterinary surgeon, who undertakes the survey of cattle diseases in India, and in this capacity brings to Dr. Lingard's notice any outbreaks or new diseases which manifest themselves in the country.

There is a probability that a bacteriological laboratory will also be started at Lahore, in connection with the Veterinary College there, and be used for the investigation of equine and bovine diseases.

Retrograde action in Madras.

273. In Madras, the step taken has, on the contrary, been of a retrograde character, as the Government have abolished the cattle disease branch of their Agricultural Department, and have given up, for the time, all attempts to cope with epidemics. The outcome of a Government Enquiry was to report that the veterinary staff was insufficient and inefficient, and that the cultivators offered opposition to the action of the veterinary officers.

These do not appear to me valid reasons for giving up the attempt to learn more about the epidemics which annually clear off so many of the cattle of the country. The first duty should be to provide a proper training for the men who are to go about the country, such as is, for instance, being provided at Poona and Lahore. When a class of properly-trained men is obtained, and efficient supervision is provided, then it will be the duty of Government to draw up wise provisions for isolating cattle when affected, and for the treatment of disease, and then to insist firmly upon these being carried out.

Such work should manifestly be part of the duties of an Agricultural Department, and not (as it has been made in Madras) that of the Education Department.

I believe that the subject of cattle diseases in India opens a great field for investigation, and that wide-spreading benefits may accrue to the agricultural community thereby.

CONCLUSIONS.

CONCLUSIONS.

274. Differences in agricultural conditions and practice which result from the varying qualities of the cattle of one district as compared with another, arise in part from external and physical causes, such as climate, grazing facilities, &c.; and in part directly from want of knowledge in breeding and selection of cattle.

The impossibility of altering physical surroundings in any material degree, prevents more than a partial modification of the agricultural differences.

To some extent, however, it is possible to modify the differences, and improvement in agriculture will be effected by providing for the better supply of stud bulls, and for their distribution throughout the country.

The people themselves will do little in this direction, and the initial work will have to be undertaken by Government. The people, however, may, as they have done in the past in the Punjab, slowly come to appreciate the advantage of obtaining good cattle.

In effecting any improvement in cattle the examples of native practice will not suffice, but the experience of Western practice must be applied also.

The people may, however, be induced to follow the practices already adopted in some parts of India, and may grow hedges for penning cattle and fodder-crops for feeding them.

The retention of Cattle-breeding Farms is very desirable, but improvements in the system by which they are managed should be made. The chief alterations desirable are, the better selection of Superintendents, and the continuance, in their position, of men who have shown themselves specially qualified for the work.

Government Experimental Farms and Court of Wards' Estates should have good stud bulls standing at them, these bulls being available for the use of the neighbourhood.

In Dairying there is but limited scope for improvement. Where a considerable European population exists, or where troops are quartered, the introduction of better methods of butter-making is likely to succeed, and it is very desirable that it should do so. With the native population not much progress will be made. The question of milk supply to troops, as well as to the European population, to jails, and other institutions, is a most important one, and demands urgent attention. The establishment of Dairy Farms is the best way to provide for the want of a pure milk supply. Where dependence has to be put on native milk dealers, the various establishments should be under control. Up to the present there has been no scientific study of dairying matters in India, and an Agricultural Chemist should be appointed to carry this out.

Encouragement should be given to the study of cattle disease, and to the employment of methods to prevent the isolating spread of epidemics. The enforcement of regulations for affected animals will have to be firmly carried out, even if opposition be at first shown by the people.

RECOMMENDATIONS.

RECOMMENDATIONS.

275. I recommend :—

The continuance and extension of Cattle-breeding Farms, and the distribution from them to villages, through Government agency, of stud bulls suitable for improving the agricultural cattle of the country.

The making Experimental Farms and Court of Wards' Estates centres for the location of stud bulls.

The establishment of Dairy Farms for the supply of Milk to Troops and Government Institutions.

The appointment of an Agricultural Chemist to investigate matters connected with Dairy Farming.

The prosecution of Enquiry into Cattle Diseases, and into the means of preventing cattle epidemics.

CHAPTER XII.

CHAPTER XII.

IMPLEMENTS.

IMPLEMENTS.

Not much scope for improved implements under existing conditions.

That improvement is possible is instanced by Beheea sugar-mill.

Native requirements must be studied.

276. PERHAPS in no direction have efforts at improving Indian agriculture been pushed more than in that of introducing new or so-called "improved" implements. Even at the present time it is not unusual, among people who speak of the *raiyat's* farming as being "primitive," to say, "What can you expect "when he uses a plough which merely *scratches* the soil?" After seeing for myself what is used, and what have been suggested for use, I am obliged to conclude that there is not much scope for improved implements under existing conditions. Not that the ones the *raiyat* uses at present are perfect, or that others have not advantages, but it is equally true that the existing implements have also advantages, and the suggested ones disadvantages, both of which have often been overlooked in the past. That there is some room for improvement is shown by the success which has attended the introduction of the Beheea sugar-mill. Still, when this has been mentioned, I confess that one cannot go much further; and if the history of the Beheea mill is looked into, it will be found that it succeeded only after a close study had been made of native ways and requirements, and after the machine had been adapted to these. I have no hesitation in saying that if this method be not followed it will be quite useless to spend time and money in trying to effect improvements. Even if a thing be good in itself, patience, perseverance, and energy are required to make the Native comprehend its advantages, but when once he is thoroughly convinced of its utility he will not be slow to follow it up. It took several years of waiting before the Beheea sugar-mill began to make its way, but when once it was introduced into a district the demand for it often exceeded the supply; this has led in the past to many imitations and new adaptations of it, some bad, some good.

Ploughs.

Iron ploughs in use at Government Farms, &c.

227. Ploughs have often been made the subject of attempted improvement, and yet the native wooden plough holds its own, and will continue to do so, I expect, whereas not one of the new kinds of iron ploughs have had more than a local fame. Almost every Government Experimental Farm has its "pet" plough; the "Kaisar," the "Duplex" (Colonel Pitcher's), and the "Watts" plough, at Cawnpore; the "Saidapet" plough and the "Massey" plough, at Madras; the "Stormont" plough, at Khándesh; the "Seebpore" plough, at Calcutta. Then there are the "S. S." (Seeley's) and the "Hindoostan" (Avery's) ploughs, both in use among the Behar indigo planters. A certain number of the ploughs are sold annually in the particular districts named; but, except among the larger landowners and the planters, they do not, it must be

Objections to use of iron ploughs.

1. Their cost.

admitted, find their way. The reasons are several, the first being that of *cost*. The *raiyat's* practice is to buy an iron share in the *bazár*, for 4 annas; this he takes, along with some *babul* wood, to the village carpenter, who then makes the plough. In Eastern Bengal a wooden plough costs 8 annas only, but Rs. 2 to Rs. 4 may be considered the general range of prices throughout India. The cheapest improved plough will, however, cost Rs. 5 to Rs. 6. The prices are as follows: the "Duplex," Rs. 5; the "Kaisar," Rs. 6; the "Seebpore," Rs. 6; the "Watts," Rs. 7; the "Saidapet," Rs. 8; and the "Hindoostan," Rs. 12, As. 8. Every attempt has been made to lessen the cost, but without avail. Until it can be brought down to the *raiyat's* standard, he will be loth even to give a fair trial to a plough the advantage of which has not as yet been made clear to him. In Gujarát (Bombay) a complete set of farming implements can be purchased for Rs. 20, and one may see, as I did, the oxen returning from the fields, drawing along, in one load, some four or five implements, including plough, bullock-hoe, leveller, and seed-drill.

2. Their weight.

A second objection which the *raiyat* makes is the *weight* of an iron plough; it is, he says, heavy to work; his cattle are not strong enough, and he cannot carry it himself, as he does his wooden plough, on his shoulder from field to field. These contentions are often true, but not always. The native plough, generally speaking, weighs about 25 lbs.; some are even lighter; the Konkan plough, for example, weighs only 20 lbs. An "improved" plough will weigh from 30 lbs. to 80 lbs. But, frequently, the native plough is considerably heavier than this. The Khándesh plough, one in common use by the *raiyat* of that district, weighs no less than 150 lbs.; it costs Rs. 5, is worked by one pair of oxen, and goes down 7 inches into the black soil, turning up heavy clods, which afterwards weather down. The Nágál plough of Gujarát (Bombay), on the contrary, weighs 60 lbs. (with yoke), and is drawn by from six to eight pairs of oxen. Why there should be this difference, the smaller number of cattle being used for the heavier plough, is hard to explain; still, it is the practice, so Mr. Ozanne assures me. The heavy Deccan plough is worked with as many as 12 pairs of oxen. At Shiyali (Madras) Mr. C. Sabanayagam Mudliar uses an "improved" plough, but his cattle are much superior to those of the surrounding country, and, being better fed, they are able to work the plough, whereas the ordinary country cattle could not. The value of the latter is Rs. 10 a pair, and those of Mr. Sabanayagam Mudliar, Rs. 50 a pair. The contention as to the greater weight of "improved" ploughs is, thus, not always correct, but yet, taking the ploughs in more general use throughout India, and omitting those on heavy black and sticky soils, it may be said that the *raiyat* can, as a rule, carry them on his shoulder from field to field or to his home. This is a decided consideration, for it may happen that a cultivator has land in two different places some little way apart; besides this, ploughs and other implements are never left out on the fields at night, for fear of their being stolen.

3. Difficulty of repair.

A third and more potent objection is the *difficulty of repairing* iron ploughs. When, occasionally, I have found iron ploughs used in a district, it has been where a proprietor owns a small foundry, and is able to execute the repairs there. This was the case at Bellary. Mr. A. Sabapathi Mudliar sells a number of Swedish ploughs here. Those used on the black soil go 1 foot deep, and require six to eight pairs of oxen; they cost Rs. 50 each, but a smaller size, used on red soil, costs Rs. 25 only. One thousand ploughs, in all, have been sold; the repairs, however, are all done at Mr. Sabapathi's factory. Mr. Sabanayagam Mudliar, at Shiyali, also has his own workshop, where repairs can be executed. Messrs. Thomson and Mylne, who make the Beheea sugar-mill, have found this same difficulty of repair, and have met it by establishing local depôts, taking back the worn-out mills from the cultivators, and replacing them by new ones, in preference to trusting to local attempts at repair. The manufacture of wooden ploughs, again, is a regular employment of the village carpenter; he forms part of the village community, and does not charge for his labour, but is kept up at the general expense of the villagers. At harvest-time he gets a proportion of the grain, and, in return, repairs and makes new ploughs all the year round. His occupation would be in great measure gone were iron ploughs substituted for the wooden ones.

4. The Native will not use an iron plough in the proper way.

There is yet another objection. The *raiyat*, if he be given a furrow-turning plough, will not use it as it ought to be used, viz., allowing it to run flat on the sole; but he will stick the point into the ground, just as he does with the native implement, and the work will be both faulty and difficult to manage. It was at Nadiad that I saw a Native working with the "Saidapet" plough; the front wheel was quite up in the air, and never ran on the ground at all. I saw the same done at Seebpore, with a plough introduced by Mr. Sen; but, when the man was shown how to use it properly, the work was very good.

Until the foregoing objections, notably the first and third (cost and difficulty of repair), are met, I do not think that iron ploughs will be used to any considerable extent.

Objections to deep ploughing in India.

278. Even if properly used, a plough that goes deep may do harm where a native one would not, viz., by turning up inferior soil, and by bringing lumps of limestone (*kankar*) to the surface.

Again, it is quite possible that, were deeper ploughing to be in vogue, the moisture, which, in the case of some soils, it is so necessary to retain, might be lost. The turning over of a furrow is not always an advantage in India; if the soil be at all stiff, the sun will rapidly bake the slice turned over; it will remain more like a brick than like soil, and will not readily pulverise again. This would not occur with the native plough, the action of which is more like that of a pointed stick running through the ground, just below the surface, say 2½ to 3 inches deep, simply stirring and loosening it. For hard and sun-baked ground, such as is often met with, no action could be better adapted, and, in a trial at Meerut, I saw an English plough completely fail on such land.

I have Mr. W. B. Hudson's (Tirhoot) authority for saying that for breaking up land in wet weather the native plough is better than a furrow-turning one, for the latter throws over a slice which will not break down readily.

In black soil, too, a plough that goes deep is bad, if no rain falls after ploughing.

The fine tilth produced by the frequent ploughing with a native plough produces a surface which will absorb water better, if rain follows, than would that left by a furrow-turning plough.

Against deeper ploughing it may also be said that there is so little manure to go on the land, that more would be lost if the soil were turned up to a greater depth.

Even when deep ploughing is employed, as by Mr. Sabapathi Mudliar at Bellary, this is only done once in four years with the Swedish plough. The native plough is used for the rest of the time.

Further, land is frequently infested with weeds, such as *kunda* (*Saccharum ciliare*), which, if buried, will readily spring up, and whereas the native plough, with its digging action, tears the weed out and brings it to the surface, a furrow-turning plough would cover it over, and give to it the very bed it required for propagating itself. So, too, would it be with a field covered with *dúb* grass (*Cynodon Dactylon*), every joint of which will grow again. For rice cultivation, nothing but a digging and stirring plough, like the native one, would do any good, working, as it does, among mud with several inches of water over it. For breaking up new land the native plough has also advantages, and somewhat resembles the tearing action of the "steam-digger."

Trials of native and "improved" ploughs.

279. At the Meerut (North-West Provinces) Agricultural Show I was a witness of work done by native ploughs brought into competition with English and "improved" ones. The field had oat-stubble on it, and but few weeds. The English ploughs, drawn by horses, were altogether handicapped by the smallness of the plots, and by the difficulty of turning, so that they had no chance of even showing quick work. But the long slice turned over (the ground being wet below the surface) soon began to dry in one mass, and looked very like forming into a hard brick under the influence of the hot sun, whereas the native plough just scraped the soil up, leaving it very fairly pulverised, and the stubble exposed on its surface. The best work, in the judges' opinion, and in my own also, was done by a "Watts" plough, for the soil was quite inverted, and yet it crumbled as it fell, covering over the stubble completely, and leaving the appearance of the field far more even than in the case of the other ploughs. The covering in of the stubble, as I shall explain presently, may be an advantage or a disadvantage, according to the nature of the weeds and grass turned in with it. But, after all, the judging of the merits of ploughs by mere inspection of the ground ploughed, partakes greatly of the nature of speculation. Before the question of "improved" as against native ploughs can be settled for India there must be actual demonstration of the superiority of the crops grown by one method as against those by the other.

I am well aware that deep ploughing has been advocated by Mr. Benson and others of great experience in India, and also that some experiments carried out on a small scale at the Cawnpore Farm seem to point to the advantage of deep as against shallow ploughing; but, although I am ready to allow, as I shall state later, that there are occasionally instances where deeper ploughing may be useful, I am obliged to conclude that it has not yet been proved that it would be of general advantage, and I could not therefore recommend it. Nor has it been shown that a mould-board is required on ploughs in India. As to the Cawnpore experiments, I do not regard them as conclusive, and they are on much too minute a scale. If the *raiyat* can be shown, not a small plot, but a whole field divided into two parts, one ploughed with the native plough, the other with an "improved" plough which he can purchase and also work with his own cattle, he may be led to believe in the superiority of the deeper ploughing when he sees a better crop produced on that half than on the other.

Numerous ploughings given by Native to his fields.

280. It has been said that if the native cultivator had "improved" ploughs he could dispense with the many ploughings which he gives to the land, and that he would thus save himself the cost of going over his field again and again, crossing and recrossing. These ploughings are always 3 or 4 in number for ordinary crops, and 8, 12, and even as many as 20, for sugar-cane and other special crops. But the answer is, that the end is achieved in time, a finer and better tilth is obtained, and the moisture is not lost. Besides, the *raiyat* has his bullocks, and it costs no more whether he works them or not, and his labour is not, as a rule, hired labour for which he has to pay, but is his own or his family's. Ploughing, too, is generally done on a mutual accommodation system, neighbours working together on one another's fields, and in turn lending bullocks for the ploughing.

It has been pointed out by Mr. Benson and others how important it is to get sowing done early, and that a crop is often lost by the land not being sown in time. But ploughing is an operation which goes on more or less the whole year round, and it is mainly where a broad stretch is put in with one and the same crop that there is the urgency spoken of, and this urgency is rather in the sowing than in the actual ploughing or breaking up of the land. I cannot see that the greater area which an "improved" plough would prepare in a given time would compensate for the disadvantages which the *raiyat* would meet in the extra cost, difficulty of repair, and the need of stronger cattle, whilst, as regards the soil itself, I think it would in most cases be left in a better condition by the native plough.

Had the *raiyat* to pay for the labour, I could understand that this item would counterbalance the cost of an "improved" plough, but this, as I have stated, is seldom the case.

Where cultivators are, as a class, inferior, it is quite possible that they may delay sowing too long, but this is hardly the fault of the native plough, and it would not occur among the better cultivators, as, for example, those of the North-West Provinces.

Cases where "improved" ploughs may be used profitably.

281. There are cases, however, where "improved" or English ploughs may be profitably used. This will be, I think, only where there are large areas to be cultivated, time being thus a matter of importance, and the economy of quick labour and improvements having room to show itself, so that the question of first cost becomes relatively of no consequence. This, in my opinion, accounts for the adoption of the "Hindoostan" plough by the indigo planters of Behar over their wide fields, but the *raiyat*, though I hear that he likes the plough, cannot afford to go to the expense of adopting it on his small plot or holding.

Both Mr. Sabapathi Mudliar, at Bellary, and Mr. Sabanayagam Mudliar, at Shiyali, are large landed proprietors, and I could understand the advantage to them of the "improved" ploughs. The latter gentleman had 287 tillage cattle, and he reckoned that he could do 13 acres with the "improved" plough in the time that the native wooden plough was doing 4 or, at most 5 acres. So this meant to him an economy of cattle.

The steam-plough.

In Behar I have seen even the steam-plough do good service, and Mr. W. B. Hudson told me that he considered it a good plan to plough with it about half an inch deeper each time, so as to bring a fresh layer of soil into use. Again, at Captain Chapman's estate at Bâti, Oudh, I saw a steam-plough at work. The "cultivator" was employed for the purpose of breaking up land and bringing it under cultivation. The land had previously formed the bottom of a lake, and such a matting of weeds and roots I have seldom seen. The steam-plough had as hard a task set as was possible to imagine, but it did its work splendidly; side by side was other land which had before been in the same state, but now, mainly as the result of steam-ploughing, was bearing magnificent crops. Had not the well-known zeal and energy of Captain Chapman brought the resources of improved machinery to bear on this land, it would be unreclaimed still, for I am sure that no implement other than the steam-plough could have possibly done the work.

Iron ploughs useful on clean land.

There are yet other cases in which I think an iron plough might do good. When land is clean and free from weeds such as *kunda* (*Saccharum ciliare*), the turning over of a furrow would bury the stubble, so as to allow it to rot and serve as manure to the land. In the trial of ploughs which I saw at Meerut the native ploughs left the stubble (oat-stubble) exposed on the surface of the soil, but with the "Watts" plough the stubble was entirely covered in, and the field was left very even and clean. If there be nothing but stubble and harmless weeds, the turning in of these would enrich the soil by the added manure provided in the decomposing stubble and grass, instead of wasting it as the native plough would. If, however, the weeds were of such a nature as to spring up again after being buried, the harm done by inverting the soil and covering them in would be much greater than the benefit received manurially.

Iron ploughs useful for sugar-cane cultivation.

In preparing land for sugar-cane, a Native will plough 8, 12, or even 20 times, in order to get deep enough, and to render the soil fine enough. Here I am sure that deep ploughing at the first would effect a great saving of labour. The possible loss of moisture has not to be considered, for sugar-cane is almost universally watered artificially. As a matter of fact, in the sugar-cultivation around Poona it is the practice to plough 7 inches deep with an 8-bullock plough.

Iron ploughs useful when rains very heavy.

Lastly, it sometimes happens that, when heavy rains come on suddenly, the surface soil may get supersaturated and water-logged, the lower layer remaining firm and dry, whereas, had the soil been deeper ploughed it would have retained the water better, and have allowed it to sink in to a greater depth, instead of soaking merely the surface soil, and then running off.

Little scope for use of seed-drills, mowing and reaping machines, threshing machines, &c.

282. If for ploughs of new designs there be but little room, still less is there for more expensive implements, such as seed-drills, mowers, reapers, threshing machines, &c. The native seed-drill will strike everyone who sees it at work as being wonderfully efficient, and leaving little to be desired. At the Saidapet Farm was an English seed-drill which had been purchased at a cost of Rs. 77, but that the *raiyat*, having already an efficient implement, would ever go to this expense is most improbable. I can, however, understand that when one watches the slow process of reaping a crop, a number of men (and often women too) squatting down, cutting handfuls at a time, laying them in bundles, and then leisurely taking these home, he will naturally think that a mowing or reaping machine would pay better in the end. But it is far otherwise, for there is no fear of rain falling and thus injuring the crop, and the *raiyat* gets all his work done in time, and very much more cheaply than if he used machinery. Experience shows that, even in England, when labour falls below a certain level, it does not pay to use machinery, and reaping by hand may still under some conditions be more economical than by machinery. So is it with threshing machines; the cultivator has his bullocks; they may as well work and tread out the grain; he has no fear of bad weather coming, and no urgent call on his time, nor hired labour to pay; besides, he gets the broken straw and chaff (*bhusa*) soft, so that his bullocks will eat it readily. At the Cawnpore Farm there is a threshing machine the price of which is Rs. 188, but it is almost needless to say that none of this kind have as yet been sold.

Threshing machines and winnowers.

283. Threshing machines and winnowers, however, demand somewhat more attention, by reason of the importance attaching to the cleaning of grain, more especially that of wheat. It is only on large estates, the "concerns" of indigo planters, and by Europeans generally, that threshing machines will have any actual use on the farm itself, and then it will be because in such cases there is a great deal to thresh, labour has to be hired, and saving of time is thus an object in view. Against them it is urged that they break and chip the wheat a good deal; that they do not separate gram from wheat; and that the *bhusa* is not rendered short or soft, as it is by the process of treading out with bullocks.

Their limited use.

Inasmuch as the planter grows his oats, barley, or other grain, not for export, but for use on his estate, the objection as to the appearance of the sample does not matter to him, and he finds, too, that his cattle, after a short time and on getting used to it, will perfectly well eat the straw thrashed by the machine. However, to meet the objection (one, I think, based on custom and idea only), in some modern threshing machines an arrangement for softening the straw has been added. Winnowing machines have met with more favour from the cultivator than have threshing machines, and he is ready, I think, to admit their usefulness. If a small and not over-expensive machine could be supplied to the *raiyat,* as an inducement towards cleaning his grain better, he might adopt it. But where exporting of wheat is practised, the grower is met by the trade difficulty that he cannot get a better price for clean wheat than for uncleaned, and as long as this is the case there will be only the inducement of saving of time to act in favour of threshing machines and winnowers. To the *raiyat* this is of no consequence, and some experiments conducted by Mr. Finucane tend to show that treading-out of corn by bullocks is more economical than steam-threshing. It may be said generally, as regards machines, that, where speed is not required, cattle-power will always beat steam-power in India.

Cattle-power and steam-power compared.

Native implements ingenious and effective.

284. Anyone who has watched the clever devices of the native cultivators in the implements which they use for harrowing, levelling, drilling, raising water, &c., will see that if anything is to replace the existing implements it must be simple, cheap, and effective. He will indeed be a clever man who introduces something really practical. I was especially struck with the effectiveness of a small hand-pick, in common use for digging holes to put seedlings into. Another useful implement is the *kodali* or hoe; I have heard indigo planters say that, if they could afford it, they would prefer to have their fields broken up with this hoe rather than with any kind of plough. The Native raises the *kodali* above his head and brings it down with force into the soil. It penetrates about 4 inches, and brings up the soil in large blocks which are left to weather down. *Dúb* grass (*Cynodon Dactylon*) can be exterminated in this way.

A short-handled hoe, called, in some parts, a *mamăti*, is in general use also, and is a most handy tool. I was very pleased, again, with a kind of wooden sledge which I saw at Igátpuri, and which is used for carrying rice seedlings from one place to another for transplanting. As many as would make head-loads for 10 men are piled upon the sledge, and it is safely dragged by bullocks over fields and roads, however rough, and sometimes to considerable distances.

Improvement must be on native lines.

In speaking of attempts made at improving native implements, I am reminded of a story which I heard about a man who tried to introduce spade digging into India. Hearing that the Native did not wear shoes, he had a broad piece of iron fixed on to the spade, so that the foot might be put on it more easily, but he quite forgot that the Native never uses his legs or feet for driving anything into the ground with force, but does so entirely with his arms. It is useless to try to make the Native do anything of this kind except in his own way. Take, for example, the case of men mending a road and shovelling stones on to it; they do not work as English labourers would, but one man holds the handle of the shovel while another pulls at a rope fixed on the lower part of the handle just above the iron. In this way the stones are scraped up on to the shovel and deposited where wanted. It is the same with ploughs; a Native, if given a double handled plough, would naturally conclude that it was meant to be guided by *two* men, one at each handle.

Improvement in implements has been effected.

285. Ingenious though native implements be, and hard though they be to improve upon, there are, nevertheless, instances to show that here and there it can be done. These I proceed to consider.

Implements sold at the Cawnpore Farm.

286. At the Cawnpore Experimental Farm several kinds of implements are manufactured and sold yearly. In 1888–89, 84 ploughs ("Watts" and "Kaisar"), 22 pumps, 24 corn-grinders (costing Rs. 25 each), and 8 chaff-cutters, were sold at the Cawnpore Farm. Sometimes implements are given out on trial, but most are sold outright.

The Cawnpore pump.

The pump sold here is generally known as the "Cawnpore pump." It is a kind of chain pump, and is admirably suited for raising water the depth of which below the surface does not exceed 20 feet. The pump has had considerable success in the neighbourhood, though it hardly comes within the *raiyat's* means; the prices are, for 3 feet to 10 feet depth, Rs. 40; for 15 feet depth, Rs. 45; and for 20 feet depth, Rs. 50. This pump is an adaptation from one brought by Sir Edward Buck from Australia. After a long series of careful trials and modifications, made under the supervision of Mr. W. J.

Wilson, of the Irrigation Department, North-West Provinces and Oudh, it was found that for depths between 15 feet and 20 feet the pump could beat all the native devices for raising water, but that at depths shallower than 15 feet or so, and again at depths exceeding 20 feet, the native appliances were superior.

Sugar-mills.

287. The success that has attended the introduction of iron sugar-mills has been touched on in passing (*see* paragraph 276). In many parts they have quite replaced the old clumsy native wooden mills. The native mills are either the *kolhu*, a mortar and pestle arrangement, in which the cane is bruised and pressed, or else wooden roller-mills, of which there are two kinds, the *gundi* or *cherki*, consisting of two, or sometimes three, upright wooden rollers, and the *belna*, used in the Punjab, and made of two horizontal wooden rollers. The wooden mills cost Rs. 20 to Rs. 30, and last about 10 years. They are hard to work, and do the pressing very ineffectually, the canes having to be passed through the rollers several times, always three or four, and sometimes as many as eight times. The only points in favour of the wooden roller-mills are, that they can be made locally, and that the canes have not to be chopped up or cut into short lengths, as is the case with the *kolhu* and with the iron mills; thus, the fibre, after pressing, is available for rope-making, and especially for ropes for wells. For the latter purpose the sugar-cane fibre is much prized, as it will stand the constant immersion in water necessitated by the employment of the Persian wheel, the method of raising water most common throughout the Punjab. Still, it has been rightly pointed out that there are quantities of *munj* grass (*Saccharum ciliare*), which would serve the same purpose quite as well.

Circumstances affecting the out-turn of sugar.

288. Anyone possessing a knowledge of the chemistry of fermentation is well aware how great may be the gain or how great the loss resulting from attention to or neglect of the numerous, and often seemingly minute, points which affect the condition of fermentable substances, such as the juice of the sugar-cane. Cleanliness, rapidity of expressing, speedy transference to evaporating-pans, rapid boiling, extent of surface exposed, removal of non-crystallisable matters, proper desiccation, and final careful storage, are considerations which favourably influence, in a most marked way, the out-turn from one and the same quantity of original material worked upon. There are a number of other determining factors, such as, the variety of cane grown, the method of cultivation, the manuring given, the influences of soil, weather, and watering, the time of cutting the canes, and the rapidity with which the canes are taken to be pressed. On all these matters knowledge in India is but limited, and a wide field is still open for enquiry. On one or two points there is some general knowledge, as, for instance, that the quicker the juice be expressed, and the more cleanly the process be, the larger will be the actual yield of sugar.

Need of scientific enquiry.

Advantages of the iron sugar-mill over the native mills.

In these respects the Beheea sugar-mill and its imitators show great improvement over the native methods. The iron mill has also the advantage of being portable, and it can be worked by the labour which the *raiyat* can command. The Beheea mill was introduced in 1873–4, and, as first manufactured, was a two-roller one, costing from Rs. 80 to Rs. 100, but within the last seven years a three-roller mill has been introduced, and is a greatly improved, though necessarily more expensive, machine. It crushes the cane before it is pressed, and thus presents it flat to the pressing rollers. I have spoken of the difficulty attending the repair of the iron mill, and how the proprietors, Messrs. Thomson and Mylne, have met this by establishing depôts throughout the country, where worn-out mills can be replaced by new ones.

The careful and prolonged study of what the Native really requires has, in this instance, resulted in the production of a machine the advantages of which have been clearly grasped by him; hence the progress made.

Instances of extension of use of iron sugar-mill.

289. I give the following instances of the extension of the use of the iron sugar-mill:—

1. Punjab.

The Punjab Administration Report (1889) speaks of the Beheea sugar-mill and its modifications as being "the only implement successfully introduced into the Punjab in late years." In Rohtak it is "driving the old "*kolhu* (native mill) out of use;" in Kapurthala the substitution of it for wooden mills is actively encouraged. At first the cultivators would not take it; but when, in 1886, as the result of competition, the price came down, first 30 mills were purchased, and later on 200 more. There is abundance of *munj* grass (*Saccharum ciliare*) at Kapurthala to serve for well ropes. In Hoshiarpur the iron mill is coming into use; the native mill (*belna*) is worked by three pairs of bullocks, and the cane has to be passed through the rollers several times.

2. Bengal.

From Bengal there are many reports of the extension of the use of the iron mill, *e. g.*, in Lohardaga, Palamau, and Rungpore. In Palamau the native *kolhu* has been driven out of use, and in Rungpore, on one Estate (Balashan) alone there are 300 iron mills in use.

3. Madras.

At Hospet, in Madras, I found that 75 Beheea mills had been sent there between January and August 1884 alone. Mr. Goud, of Hospet, has since pushed the sale of iron mills largely, and they are highly appreciated; there are now 600 Beheea mills in the district, and the wooden mills are all gone. The iron mills are hired out for one rupee per day. Mr. Goud told me that there is a large field for iron mills in Hyderabad, as the people have not yet given up their wooden mills.

4. Bombay.

From Bombay it is reported that in one village alone, viz., Velur, in Valva *taluk*, Satara, there are 120 iron mills in use. The mill is pushing its way in the Deccan, but in Gujarát, with few exceptions, the wooden mill still holds sway.

5. North-West Provinces.

It is in the North-West Provinces that most advance has been made, and iron mills are almost general. The Beheea firm have depôts at Saharanpur and elsewhere.

Respective merits of rival iron sugar-mills.

290. It is not for me, without special investigation and trial, to go into the respective merits of rival iron sugar-mills, but I would say that these are legitimate points for Provincial Agricultural Departments to enquire into. Experimental Farms are places where such trials should be exhaustively carried out.

Work for Agricultural Departments.

Shallow evaporating pan.

291. Passing from the sugar-mill, I would next mention an implement the extended use of which would be attended with much benefit, I mean the shallow iron evaporating-pan for boiling the expressed cane-juice in The more rapid evaporation effected by the broad shallow pan, as against that with the narrow and deeper pan generally used, would give much less opportunity for secondary fermentations setting up, and for impurities finding their way into the juice. Both of these circumstances will cause a loss in the amount of crystallisable sugar yielded. In Palamau (Bengal) the shallow pan is in use, but not in Lohardaga, nor yet in Dacca; in the latter earthen pans are employed. In Gujarât (Bombay) the use of the shallow pan is universal, but it is not known in Bassein, where deep narrow copper pans are in vogue.

Sugar "turbine"

292. Still more recently a centrifugal "drier" or sugar "turbine" has been introduced into India, it effects the rapid separation of the molasses from the crystals of sugar. Though worked by hand, and very efficient, it is of necessity expensive, and cannot as yet be expected to be applicable except where sugar is made on a tolerably large scale, or by a combination of *raiyats*. A sugar "turbine" of 36-inch size will deal with 50 maunds of crude sugar in 10 hours.

Other implements.

293. Ploughs, winnowing machines, and iron sugar-mills are about the only implements which the Natives have in any way appreciated. and, among these, the success of the last-named has been much the most marked.

Of other implements, I must say that it is not likely that they will enter to any extent into the *raiyat's* agricultural system. Chaff-cutters may, perhaps, be here and there appreciated, and a few have been sold at Cawnpore; so, too, may it be with corn-grinding machines. Others, such as bone-mills, water-pumps driven by wind, cream-separators and other dairy implements, mowing, reaping, and threshing machines, elevators, cotton-presses, &c., will only be employed on large Estates, on Grass Farms, or in connection with towns.

A portable oil-mill wanted.

I can, however, indicate one implement of which there is need; this is a portable oil-pressing mill. At present the mortar and pestle arrangement adopted in the native wooden oil-mill, though effective, is cumbrous. Its cost is Rs. 50. In consequence, all the oil-seed has to be brought to a place where there happens to be a mill. What is wanted is an oil-mill of a domestic size, which a woman can work inside the enclosure of her own house. A way seems open for someone to replace the present oil-mill with some such machine as that with which Messrs. Thomson and Mylne supplanted the wooden sugar-mill.

Improvement by transference of use of native implements.

294. But improvement in implements, or rather in the cultivation by their means, need not always proceed *from outside* existing Indian practice. Sometimes it may be found that in a particular district an implement is unknown, or is inferior to one in use elsewhere, and improvement may be effected by the transference of practice. At a little distance from Ferozepore, on the way to Ludhiana, Mr. E. B. Francis showed me some light sandy land on which, when a shower of rain falls soon after sowing, a crust is very apt to form, so that the young shoots cannot force their way through it. This is especially the case with barley, and rather less with wheat; when it forms, the people habitually re-sow the crop, for they have no implement corresponding to a harrow. I have instanced how careful the Behar indigo planter is to break up this crust the instant it forms, using a bullock-rake or harrow having spikes some 8 inches long, and penetrating about 2 inches into the soil. An implement of this kind, if introduced at Ferozepore, would entirely dispense with the necessity of re-sowing. The improvement here would consist in a transference of native methods, not an importation of foreign ones. A similar instance is that of a seed-drill for "dry" (unirrigated) cultivation. In the northern or Telegu portion of Madras such a drill is used, but not in the southern or Tamil portion, where the grain is sown broadcast on "dry" land.

Trials of implements at Experimental Farms, and distribution of implements by them

Need of greater care than in the past

295. Experimental Farms have in some cases been, and ought to be still more, the places where different implements should be put to thorough tests. Subsequently they might be the centres for distribution of such implements as had been found to be really beneficial, and which the *raiyat* would be able to avail himself of. But much more care must be exercised, I think, than has been given in the past, before a machine goes out with the Farm's *imprimatur* on it. If it be found to be useless, or if it be beyond the *raiyat's* reach, it will not redound to the Farm's credit, nor to that of the Agricultural Department of the Province. I have seen at Experimental Stations implements which there was not the remotest chance of the *raiyat* ever using, and, unless these are really required for the economical management of the Farm, their presence for demonstration purposes is a useless expense.

Desirability of associating men of scientific attainments with agricultural enquiries.

296. In conclusion, I would remark on the desirability of employing in agricultural enquiries men of scientific attainments, such as engineers, chemists, botanists, geologists, &c., whichever the circumstances of the case demand. If this be not done, such experimental trials will lose the greater part of the value that might attach to them, and there will be no guarantee as to their being properly, that is, scientifically, conducted. On the other hand, real value may be derived from such experiments when carried out on a right system, and with scientific help. It is most desirable, therefore, that Agricultural Departments should employ in their enquiries the aid of skilled experts.

CONCLUSIONS.

CONCLUSIONS.

297. In considering the differences of agricultural practice which arise from the possession, in one district, of implements unknown in another district, we have passed entirely beyond the second main division of differences laid down in Chapter II. No longer do external surroundings enter, but it is altogether with the third division that we have to do, viz., the differences which arise directly from want of knowledge.

On this account the people can do little or nothing to effect improvement, while, from the peculiar conditions of Indian agriculture, the Government cannot do much either.

In brief, I do not think that there is any great scope for improvement in the *raiyat's* farming implements.

Further, where any improvement is possible, it will come mainly from without and not from within, *i. e.*, by the application of Western science to native ways and requirements. Very occasionally only will it be possible to extend the use of a native implement already in use in one part but unknown in another.

The introduction of the Iron Sugar-mill has, however, clearly shown that marked benefit may arise from the employment of machinery of Western origin, provided this be carefully adapted to the needs of the Native. Unless this provision be taken failure will certainly result.

Similar benefit may result from the use of shallow evaporating-pans for sugar-boiling, and there is an opening for a portable oil-pressing mill.

Although in some instances deep ploughing is advantageous, this is not generally the case in India, and I do not think that iron ploughs will take the place of the native wooden ones until the difficulties as to initial cost and repair can be met.

For winnowing machines, chaff-cutters, and corn-grinders a limited future may be open, but other implements, such as mowers, reapers, threshing machines, elevators, bone-mills, cream-separators, &c., a use will only be found on large Estates, Grass Farms, or in towns.

The work of Government in connection with the introduction of new implements is to submit them to exhaustive trial at Experimental Farms, and to work them side by side with the native methods.

If the advantage of a new implement is clearly demonstrated, then the Provincial Agricultural Department should make its Farm the centre from which to distribute the implement, and its Shows the means of exhibiting the machine at work.

In conducting any exhaustive trials the Provincial Agricultural Departments should make use of experts in the particular branches of science connected with the enquiry.

RECOMMENDATIONS.

RECOMMENDATIONS.

298. I recommend:—

The exhaustive trial of new Implements at Government Experimental Farms.

The association, in trials of Implements, of men specially skilled in the respective sciences concerned in the enquiry.

The distribution of approved Implements from Government Farms, and the utilisation of Agricultural Shows for demonstrating the working of such Implements.

CHAPTER XIII.

CHAPTER XIII.
—
CROPS AND CULTIVATION.

CROPS AND CULTIVATION.

Scope of this chapter.

299. A DESCRIPTION either of the crops of India or of their cultivation is not called for in my Report, and I shall therefore only deal with these matters in so far as any suggestion for their improvement can be made.

Possibility of improvement.

300. I have remarked, in earlier chapters, upon the general excellence of the cultivation; the crops grown are numerous and varied, much more, indeed, than in England. That the cultivation should often be magnificent is not to be wondered at, when it is remembered that many of the crops have been known to the *raiyats* for several centuries; rice is a prominent instance in point. Yet, that improvement is not impossible may be seen in the spread, within recent times, of indigo and jute cultivation, the introduction of tea-planting, the raising of the potato and other vegetables, the growing of maize, &c.

Changes produced by export.

301. The increasing demands of other countries for wheat, oil-seeds, cotton, &c., have exercised an important influence upon the systems of Indian agriculture, and, whereas the *raiyat* formerly looked to his field yielding him a crop which would provide grain for himself and his family, as well as straw for his cattle, the element of export has now entered into his calculations, and has marked changes in the kinds and extent of the crops grown.

Increase in wheat area.

Thus, in the Punjab, in the year 1888–89 alone, an increase of 11 per cent. was recorded in the area devoted to wheat-growing, no less than 54 per cent. of the *rabi* or winter-cropped portion, or 31 per cent. of the whole cropped area of the year, being now taken up by this cereal.

In the Hoshiarpur district, sugar-cane is no longer considered the best-paying crop, but its place has been taken by wheat, sugar-cane coming next in importance, and then cotton.

Review of improvements in cultivation discussed in preceding chapters.

302. In the preceding chapters much has been said in regard to improvements which can be effected in crops or in cultivation, through internal and external means. It has, for instance, been shown that the breaking down of caste prejudice would induce better cultivation; that the extension of systems of irrigation and of embanking land, together with improved working of the *taccavi** rules, would enable larger crops to be grown; and that the better conservation and increased supply of manure, the provision of "Fuel and "Fodder Reserves," the growing of fodder-crops, the better breeding of cattle, the adoption of certain implements, and other means, would directly improve agriculture. I will not refer again to these methods in the present chapter, but will confine myself to a consideration of possible improvements not already treated of, and which are of a kind more nearly connected with the individual crops themselves. Such improvements are those which may result from the practices of fallowing, rotation, selection and change of seed, or from the introduction of new crops or new varieties of crops, the extended cultivation of particular crops, and so forth.

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* *See* footnote page 81.

The present chapter.

303. When discussing, in Chapter V., the question as to whether the soil of India is becoming exhausted or not, I referred to the practices of Fallowing and Rotation (*see* paragraph 49). The more special treatment, however, of these subjects comes in here. Fallowing is quite well known to the Indian cultivator, and its value is understood, but the practice of it is greatly reduced by the pressure of population on the land, and by the increasing demands made upon the soil. The instances cited in paragraph 50 bear testimony to this, although the evidence also shows that the *raiyat* will fallow his land if he can afford it. In some of the cases quoted, a prolonged fallowing and renovation of the land was effected by allowing it to revert to its original state of forest and jungle, and then, after a time, clearing it for crop-growing. As population presses and cultivation spreads, fallowing will, of necessity, be employed even less than at present, and, therefore, it is of no use to advocate it as a remedy. The *raiyat* will do it, as I have said, if he can afford to, and he will do it if he is obliged.

Fallowing not a practicable remedy.

304. It is quite a mistake to suppose that Rotation is not understood or appreciated in India. The contrary is the case. Frequently more than one crop at a time may be seen occupying the same ground, but one is very apt to forget that this is really an instance of rotation being followed. It is not an infrequent practice, when drilling a cereal crop, such as *juár* (*Sorghum vulgare*) or some other millet, to put in at intervals a few drills of some leguminous crop, such as *arhar* (*Cajanus indicus*). The grain crop grows the more rapidly and keeps the other back; it is duly reaped when ripe, and the land which it occupied is then ploughed. The pulse crop, thus free to extend itself, grows on apace, spreading partly over the intervening area, and becoming the crop of the field, until, in due time, it too is reaped. The next year the same "mixed crops" may be sown again, and thus to the casual observer it might appear that continuous cropping was being practised. This, however, is not so, for there is a perfect rotation of cereal and legume. This is, perhaps, the simplest form of rotation, but there are many more complicated than that of "mixed-cropping." The latter, however, has the advantage of providing against the fluctuations of

"Mixed crops."

Advantages of "mixed cropping."

season, for, should one crop from any reason fail, the other will probably stand and cover the ground. This is a matter of no small moment, seeing that a *raiyat's* entire holding is only a few acres in extent, and that it has to feed him, his family, and his cattle, and to pay the rent as well. In an experiment made at the Bhadgaon Farm it was found that a greater profit was obtained by intersowing cotton with *juár* or *arhar* than by growing the cotton alone.

"Mixed crops" are not confined to two in number on the ground at the same time, but several sorts may be sown together; for instance, wheat, barley, and gram (*Cicer arietinum*), or these with rape (*sirson*) as well. Wheat and gram often occur together, so also wheat and linseed, the latter frequently fringing the wheat field, and thus serving to keep cattle off, inasmuch as they will not touch the growing linseed. Cotton with *juár*, cotton with *arhar*, and wheat with mustard, are other instances of "mixed crops." There are many systems in ordinary use which are far more complicated than the above. For instance, not only may there be the rows of crops side by side, as noticed above, but the alternating rows may themselves be made up of mixtures of different crops, some of them quick-growing and reaped early, others of slower growth and requiring both sun and air, and thus being reaped after the former have been cleared off. Again, some are deep-rooted plants, others are surface feeders, some require the shelter of other plants, and some will thrive alone. The whole system appears to be one designed to cover the land, and thereby to prevent the bareness and consequent loss to the soil which would result from the sun beating down upon it, and from the loss of moisture which it would incur. It is known also that the process of nitrification in soils is much more active when a growing crop is on the ground than when the latter lies fallow.

Rotation.

305. In most parts it will be found that, whilst rotation is practised, no regular order in the crops forming a rotation is kept to, but that considerable latitude is exercised in their choice. Nevertheless, the crops will generally be found to follow certain rules of rotation, such as cereal after legume, and fruit-bearing crop after bulbs. The one crop with which rotation is not practised is rice. Why this should be so may be better understood when the conditions under which rice is grown are considered. Rice flourishes on silt-renewed lands that need little or no manure, and which are plentifully supplied with water. The water itself, by its constant renewal, probably makes the soil-constituents more readily available. Under these circumstances the rice plant becomes semi-aquatic in character, and is more independent of manure, and of the manurial benefits effected by rotation. Differences in the mode of cultivating rice may, however, be followed; thus, in some parts of Bengal it is the rule to sow rice broadcasted one year, and transplanted the next.

Rotation not practised with rice.

Instances of Rotations practised.

306. The following are instances of Rotations practised in different parts :—

1. Punjab.

In the Punjab :—

On "dry" (*barani*) land.	On rich land.	
Fallow.	Cotton.	Wheat or barley, with gram and oil-seeds.
Wheat and gram.	*Senji* (a millet).	*Juár* or *bájra*, with pulses.
Chari (fodder *juár*).	Sugar-cane.	Fallow.
Fallow.	Maize.	Fallow.
Fallow.	Wheat.	Wheat or barley (as above).
Wheat and gram.	Cotton.	*Juár* or *bájra* (as above).
Chari.		

2. North-West Provinces.

In the North-West Provinces :—

Indigo.	Millet.
Barley and peas.	Fallow (green crop ploughed in).
Fallow.	Wheat or other winter cereal.
Wheat.	Millet.

3. Bengal.

In Bengal :—

In Lohardaga, on uplands.

1st year, *marua* (a millet).
2nd „ *gora* (rice).
3rd „ *urid* (pulse).
4th „ *gondli* (millet), followed by an oil-seed or pulse.

In Palamau.

(*a*)	(*b*)
1. Cotton.	1. Maize or some millet.
2. Gingelly (oil-seed).	2. Wheat for two or three years.
3. *Kodo* (millet).	3. A leguminous crop for a year or two.

In Dacca.

(*a*)	(*b*)
1. Potatoes.	1. Jute.
2. Rice or jute.	2. Tobacco or a pulse crop.
3. Chilies.	

In the instance from Lohardaga there is a four years' rotation, giving five crops, of which three are cereals. In Palamau the same cold-season (*rabi*) crop, whether cereal or pulse, is never grown on the same land for more than two or three years successively, but it is always followed by a *rabi* crop of a different character or growth.

4. Central Provinces.

In the Central Provinces :—

Juár, *kodo* (a millet), and *arhar* (pulse) sown together.
Wheat.

5. Bombay.

In Bombay :—

In Gujarát.

1. Cotton.
2. Wheat or *juár*.
3. Gram or some pulse.

In Surat.

1. *San* hemp ploughed in and followed by sugar-cane.
2. Sugar-cane.
3. Rice with *arhar* or some pulse.
4. A pulse crop.

In Máhim.

1. Betel vine, two years.
2. Ginger.
3. Sugar-cane.
4. Plantains, two years.
5. Rice or *rági* (*loc.* *nágli*), on *rábed* seed-bed.

In the Konkan, on hill land.

1. *Nágli.*
2. *Warai* (a millet).
3. Niger seed (oil-seed), then Fallow for five to six years.

A general rule in "garden-land" rotation in Gujarát is :—

"Tap-roots follow fibrous, and that which bears fruit should follow "bulbs."

The rotation instanced at Máhim is a seven years' course on "garden-land," but another, of five years' duration only, is made by the omission of betel vines, and is also practised largely.

6. Madras.

In Madras :—

In Coimbatore, though there are variations caused by early or late rainfall, a frequent practice on "dry" land is to sow *cholum* (*Sorghum vulgare*) or gingelly (*Sesamum indicum*) in May, to reap in August, and to follow in October with cotton or gram. On "garden land" *rági* (*Eleusine Corocana*), sown in May, is followed in October or November by tobacco, and this by *cholum* in the next April. Sugar-cane is followed by cereals.

In Tinnevelly, cotton succeeds *kambu* (millet) and pulses ; it is sown with the cereals, and remains after that crop is reaped.

Improvement of Rotations.

307. Sufficient proof has now been given that rotation of crops is both understood and practised. Whether the rotations are of the best kind, or whether they might be improved upon, is another matter, and one upon which my limited knowledge of the crops and their habits does not allow me to give an opinion. I have frequently read statements as to inferior cultivation being the result of injudicious rotations, but I have seldom seen any suggestions as to what should be done instead. Much must depend on the climate, the nature of the soil, the facilities for water and manure, &c. In England, the use of artificial manures enables great liberties to be taken with rotation, and may even cause it to be partly suspended in case of the market favouring the growing of a particular crop. In the same way it is more than likely that the *raiyat* will, in general, be the best judge of what his land can do.

Selection and change of seed.

308. Though the *raiyat* may have little or nothing to learn about rotation, he is very ignorant in regard to selection and change of seed. In this respect the Indian cultivator might well follow the European planter, as, for example, in the careful selection of indigo seed. Even in Gujarát (Bombay), where the indigenous cultivation is excellent, the benefit of selection and change of seed is not appreciated ; throughout Bengal it is unknown, except in the case of indigo. The Hoshiarpur (Punjab) Settlement Report says, "It is to be regretted that the cultivators should ordinarily exercise so little care in the selection of "seed for their crops." The Rawal Pindi Settlement Report speaks of the absence of careful seed selection by the cultivators. The same neglect is shown in the Central Provinces ; both here and elsewhere this is especially the case with cotton ; indeed, the complaint that the long-stapled varieties, such as Broach, are deteriorating, is traceable to the want of selection of seed, or rather to a mixture of seed being given to the cultivator to sow.

Not generally practised.

There are several proverbs, such as one which Mr. Benson found current in Kurnool, pointing to the desirability of selecting seed. "As you give gifts to the deserving, so select 'seeds for your soil," runs the proverb, but the practice is different to the precept, and seed is not habitually selected.

Now and again selection of seed is practised to a certain extent. Thus, in the Rawal Pindi Settlement Report Mr. F. A. Robertson points out that the Arains or Malliars are the best cultivators, and that they select their maize seed. The crop is, in consequence, far superior to that grown by the other cultivators. He adds, "What is wanted is careful selection of "seeds by the cultivators, and the fostering care displayed "by the Malliars in bringing their crop to maturity."

At Hoshiarpur I found that, when *juár* was grown as a fodder-crop, fresh seed was obtained every year from another district, viz., Ludhiana.

It is very certain that if more care were taken in the selection of potatoes for seed, and in change of seed, the crop might be greatly improved.

The cause of the neglect.

309. The root of the mischief lies in the system by which the cultivator is not his own seed merchant, but is entirely dependent on the *baniya, mahajan,* or similar individual of the money-lending class. These men supply the *raiyat* with seed, charging interest at an exorbitant rate, for they know that he *must* have seed or else he cannot grow his crop. The accounts between merchant and cultivator, thus begun over seed transactions, are seldom allowed to lapse, and often assume enormous proportions, leading to mortgaging of land and other evils. It is in this that the utter improvidence of the *raiyat* is shown, and that he frequently becomes a prey to the money-lender. Having saved no seed for himself for resowing, and having no money to purchase elsewhere, he has recourse to the means so ready at hand, and the land is practically charged with an extravagant burden, and one of the *raiyat's* own creation. It is strange, indeed, what a hold the money-lenders have on the people; in one district of the Central Provinces I found well-to-do cultivators, who could easily have purchased their seed in the open market or from other cultivators, but who, nevertheless, went to the *mahajan* for it, because they liked to be on good terms with him; so they regularly borrowed from him, and paid him back at the end of every half-year.

Money-lenders.

Improvidence of the *raiyat.*

Mr. Fuller, in one of his Reports, says, "Borrowing seed-"grain is incompatible with improvement by seed selection," and this is strictly true. But the practice has become almost universal, and the *mahajan* is a regular institution, so that improvement cannot proceed to any great extent unless by an alteration in the *raiyat* himself.

Cause of deterioration of cotton.

In the case of cotton, the cultivator sells both fibre and seed, and the grain merchant, receiving many small lots of seed, often of different varieties, mixes them up together. Later on, the grower buys back the mixed seed and sows it, and, thus, purity of seed and uniformity of quality are altogether lost.

Selection and distribution of seed by Government at Experimental Farms, &c.

310. As the *raiyat,* even under the best of circumstances can hardly free himself from resorting to the money-lending grain merchant, because he has nowhere else to go for his seed supply, it becomes one of the most useful acts which Government can do, to provide the cultivator with seed, or rather, with the facilities for obtaining it.

Good work already done.

Extended action needed.

The business of a seed merchant, as understood in Europe, is unknown in India, and I do not think that there would be any scope for it, even if it were desirable to introduce it. But Government, by means of its Farms, might serve a most useful end in growing pure seed and in making it available for distribution to cultivators. This has not been altogether neglected in the past, and the Cawnpore Farm of the North-West Provinces especially, and also the Farms of the Bombay Government, have done good work in showing the advantage of selection and change of seed, and in the establishment of distributing centres for good seed. But much more extended action is required before the cultivator can be rendered independent of the grain merchant. The Farm at Cawnpore cannot now supply enough seed to satisfy the demands made upon it. There ought to be not only Experimental Farms, but Seed-growing Farms, where the *raiyat* could buy pure and good seed at a moderate cost, instead of, as he does at present, going to the *bazár* and getting what he thinks looks best. If the experiments at some of the Government Farms were curtailed, and more land were laid out in producing selected seed for distribution to the district around, I think more good might be done. This work does not imply the existence of a distinctly *experimental* farm, nor of a skilled staff, but there might well be, under Provincial Agricultural Departments, a Seed Farm in each district to provide for the requirements of that district.

The Bombay Agricultural Department distributes seed in Sind to *zemindars* on the simple condition that the amount of seed given is subsequently returned to Government.

At Nadiad the local Agricultural Association has established a seed store in the town, for the sale of selected seed at cost price. The plan is slowly making way with the cultivators.

Court of Wards' Estates, again, would be very suitable places at which to grow selected seed, and they might act as distributing centres for the supply of seed to the neighbourhood.

Facilities should be given for purchase of good seed.

Not only must the seed itself be available, but encouragement and facilities must be given to the purchase of good seed. The system of *taccavi** advances is applicable to the case of seed-purchase, equally as to the digging of wells and purchase of cattle. But in the case of seed, advances are given only in time of scarcity, and not in ordinary times. There would be no need of such restriction if Government became the grain supplier. As long as the cultivator resorts to the money-lending grain merchant the working of *taccavi* advances for purchase of seed will be unsatisfactory, but if Government were to supply the seed from their Farms or from other distributing centres, the cultivator might be freed from having to resort to the *baniya*. In other words, Government might practically become the *baniya* themselves.

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* *See* footnote, page. 81.

Introduction of new varieties.

311. Improvement may be effected, not only by selection and change of seed, but by the introduction of new varieties. Experimental Farms have, in this matter also, done very useful work in showing what new varieties are likely to have any permanent value, and in some cases considerable benefit has accrued from their distribution. At the Cawnpore Farm other varieties of wheat than those in local use have been tried; the Muzaffarnagar variety, in particular, meeting with considerable success. Thus, in 1888–89, about 40,000 lbs. of Muzaffarnagar wheat were distributed, and over 7,000 lbs. of seed oats. The Bombay Agricultural Department also does a very considerable work in trying new varieties of seed. The 1888–89 Report states that a soft white variety of wheat from the North-West, after acclimatisation, was distributed to 65 *zemindars* in Sind. It proved very successful, and 2,815 acres in the Nára Valley (being one-eighth of the total wheat area) had been sown with it. It is found to ripen quicker, to yield more grain and more straw, and to be less liable to "rust" than the hard local variety; besides, the price obtained for it is Rs. 2 As. 14 per maund, as against Rs. 2 As. 8 per maund for the Sind wheat. The Report further says:—"the experiments show "that the interchange of seed between various Provinces is most "successful." In Reports of the Bengal Agricultural Department it is stated that Buxar wheat has been successfully introduced into Bhagalpur, and has produced a wheat which fetches quite 6 annas a maund more than the local grain.

1. Wheat.

2. Cotton.

Mr. Ozanne, the Director of the Bombay Agricultural Department, has made many experiments with a view to improving the quality of cotton produced in the Presidency. American varieties of cotton have been acclimatised at Dhárwar, and then transferred to Khándesh and other districts, and an endeavour is now being made to perpetuate the long-stapled varieties of Berar cotton known as *bani* and *jari*. It is found that the American varieties give a smaller yield until they have been acclimatised to a district, and hence the cultivators do not care to risk the immediate loss incurred. This militates against the spread of the growth of better varieties of cotton in India.

3. Maize and Sugar-cane.

It is very certain that, not in wheat and cotton alone, but in maize and sugar-cane cultivation too, improvement may be effected by the introduction of varieties new either to a particular district or to the country.

Need of caution in trying new varieties.

It is necessary, however, to interpose a caution against trying changes of this kind on any but an experimental scale at first. There should also be some *primâ facie* indication, such as would be derived from a similarity in the climatic conditions of the respective regions, that the transference is one likely to succeed. The unsuccessful attempts to introduce English wheats into India are instances of want of understanding of the relative conditions of English and Indian agriculture, and Provincial Departments of Agriculture would do well to consider these before they accept the assurances of enterprising seed merchants in England. The season in India is too short for English wheat to mature, and, although grown in the cold season, the wheat does not (except in the hills) lie under snow, nor is it subject to severe frosts. Consequently, 20 to 30 days of heat will cause it to grow rapidly, and if the grain be not formed by February the crop will be prematurely ripened. What is wanted is not so much to try exotic or imported seed, which may be good one year and fail to produce good results the next, but to try indigenous varieties which have already been found by the experience of other districts to be well adapted.

Use of Experimental Farms in distributing new varieties.

When, however, a new variety has been found to be, beyond doubt, superior to a local one, Experimental Farms can do a most useful work in distributing the new seed; as also in selecting and perpetuating pure and good local varieties.

Introduction of new crops.

312. It is not alone in the introduction of new varieties, but also in that of new crops, that improvement is possible. Here, again, Experimental Farms have not been backward. and. though it may be asked how many of the new crops tried at these Farms have ever been fairly introduced, I maintain that such work of enquiry is a legitimate one, and that it is the necessary fate of all experimental work that only one or two things out of a hundred tried may possibly succeed; nevertheless, the record and observation of what has been done will not be altogether thrown away. It will be known what has been tried, and so need not be tried again; also, what may possibly succeed under other circumstances.

Introduction of new crops may take place in two directions. The crops may be either entirely new ones to the country, or merely new ones to the particular district.

The history of the present crops of India is one telling largely of importation; such imported crops are,—the numerous millets (the principal food grains), maize, tobacco, tea (though the shrub was subsequently found and cultivated in India), coffee, the potato, and many other kinds of vegetables. There is, therefore, no reason why other crops should not be imported also. At Government Stud Farms lucerne has been introduced with much success.

Where a crop is not known to one district, but is to another, improvement may often be effected by the transference of practice. There is little doubt that the cultivation of the potato might with advantage be introduced to fresh districts. At Salem (Madras) vegetables such as the onion, the pumpkin, the egg-plant, &c., are grown in profusion, but the potato is not raised; the people say they do not know how to cultivate it. Wheat might be grown in parts of Eastern Bengal where it is not now known. Oats might usefully find a wider sphere than they occupy at present.

Extension of cultivation of existing crops.

313. An impetus can, in some cases, be given to the extended cultivation of remunerative crops, such as sugar-cane, potato, &c. This will, however, result rather from the adoption of better modes of cultivation or of manufacture, than from other means. At Dongasara, in the Central Provinces, I found evidences, in the disused stone presses still lying about, that sugar-cane was formerly grown here, but now it is not cultivated. With the help of the new iron sugar-mill the cultivation of sugar-cane might once more be profitably followed. Potatoes grow very well in Dacca, but the acreage under this crop is very small, and might readily be increased. I believe that good may be done also in increasing the variety of crops grown, and in obviating thereby the placing of so much dependence on one crop alone. Tanjore, for example, depends practically upon rice, Bellary upon cotton. If other crops were more extensively cultivated, the consequences attending the failure of the staple crop would be minimised.

Diseases of crops, and insect attacks.

314. I wish to note here the desirability of gaining more knowledge as to the diseases to which crops are liable, and of the injurious insects which attack and destroy them. It is satisfactory to note that the Government of India have, with the co-operation of the Trustees of the Indian Museum, Calcutta, made a beginning in this direction, and that the services of Mr. E. C. Cotes, of the Entomological Department of the Museum, have been utilised, not only for teaching at the Forest School, Dehra, but also for investigating the history and prevention of insect attacks on plant life.

The valuable services which, in England, Miss E. A. Ormerod has rendered to agriculture, may be taken as illustrative of the good that may be done similarly in India.

Out-turn of crops.

Crop experiments.

315. There is still much to learn in respect of the out-turn of different crops. A system of "crop experiments," or experimental cuttings, is conducted in the Bombay Presidency and in a few other parts, and has been found useful for Settlement purposes. The trials are conducted by District Officers, the crops over small accurately-measured areas being cut, and the produce weighed. The object is not only to get to know the yield of different crops, but also to find out the incidence of assessment on the value of the gross produce, and thereby to ascertain if the land-tax has been justly estimated. In a few cases further special experiments over entire holdings are made, for the purpose of ascertaining whether a fair return is given for the cost of cultivation, &c. Considerable difficulty is experienced in getting these trials carried out accurately, and the returns need to be subjected to careful examination and criticism before being accepted. I regard the work, however, as a very desirable one to carry on, for, by the compilation of these returns, considerable agricultural knowledge may be gained as to the yield of crops in different parts of a Province, as well as of India generally, while, as stated, they will also be found useful for assessment purposes.

Transference of method.

316. Improvement, both in crops and in their cultivation, may be effected by a transference of method from one country or locality to another. The introduction of new crops and of new varieties affords in itself instances of this improvement by transference of method.

Many of the improvements which I have summarised in paragraph 302 come under this same head, and are connected more or less nearly with cultivation. I shall, therefore, only give now some improvements which are directly concerned with actual crop-growing.

Improvement of rice cultivation.

Sowing of rice.

317. Rice, in its many varieties, is not sown in the same way everywhere. Sometimes it is sown broadcast, sometimes it is transplanted from seed-beds. It is known that the out-turn of transplanted rice is greater than that of broadcasted, and only the better varieties of rice are used in the former case. Yet there are districts where transplanting is the rule, others where it is not, and the question naturally arises whether the better practice might not be successfully introduced into districts where it is not known. Mr. Fuller pointed out to me that rice is sown broadcast in the Raipur and Bilaspur districts of the Central Provinces, and is not transplanted even on the best lands. Enormous waste of seed is thereby incurred. In the Sambalpur and Bhandara districts, on the contrary, rice is very extensively transplanted.

Manuring of rice lands.

The rice cultivation of Tinnevelly is far superior to that of Tanjore, and the out-turn is much better. The difference is the result of the inferior cultivation in Tanjore. Whereas in Tinnevelly it is the rule to manure the land by ploughing in green crops, wild indigo, &c., this is not done in Tanjore. The practice of manuring rice land is now becoming much more frequent. At Ahmedabad I found that it was the rule to manure with cow-dung; tank silt was also used. At Belgaum all rice fields are manured with cow-dung, and with ashes from the villages.

Ploughing of rice lands directly after harvest.

Again, in the better districts it is the practice to plough up the land directly after the rice crop is cut. This is done in Tinnevelly. Before being told of this, I had, when in Tanjore, been struck by the hard and baked surface of the rice fields after harvest, and I could not help thinking that an improvement might be effected if the land were ploughed up while the moisture was still in it. If the land is left to get hard and dry, evaporation is more rapid, and when rain comes it is not so readily absorbed as when the land is in a finely-tilled state. But if the field were to be ploughed after harvest it would be easy to work, the stubble would be allowed to rot, and to mingle with the soil, subsequent ploughing would be rendered much easier, and a quickly-growing green or "catch" crop might be meantime sown. This is not universally practicable, I am aware, but there are very many parts where it might be done quite well. At Shiyali (Tanjore) the cultivators allowed that, after the rice was cut in February, a crop of grain might be sown and reaped green in April, but they said it was too much trouble to do it. Later on, I heard of parts where this was actually done. At Máhim, if there is enough moisture after the rice is off, a crop of gram, and sometimes even of castor (*Ricinus communis*), is sown. At Belgaum almost all the rice land gives a second crop, either of peas, lentils, or barley. The seed is thrown on in the rough, and there is no great preparation of the land beforehand. I find that Mr. Nicholson, in speaking of Coimbatore, remarks on the advantage that would follow the ploughing of waste lands after harvest in November, thus enabling the November rains to be more utilised. From the Reports of the Bengal Agricultural Department I take the following:—

> "Rice has been so long cultivated that there is little to teach the "*raiyats*, but those of one part can learn a great deal from those of "another; *e. g.*, the Burdwan *raiyat* always uses oil cake. Again, ploughing "of rice lands after harvest, to weather and sweeten the soil, would be an "advantage . . . .; in parts of Bengal *raiyats* spread hide salt to get "rid of what they call a 'disease,' but which is really the consequence "of leaving the land unploughed."

Waste of seed sowing rice.

Great waste of seed in sowing rice is undoubtedly often incurred. Mr. Nicholson found that in Coimbatore 80 to 100 lbs. of seed-rice per acre were used in the transplanting process; he estimated that on the 87,000 acres of rice land in the district no less than 3,100 tons of seed, costing Rs. 1,40,000, were used.

Mr. Sabanayagam Mudliar is also of opinion that far more rice is used in sowing than is necessary, and at Shiyali he adopts much thinner seeding than is usually practised around him. As instanced above, there is much waste of seed when, as in the Raipur and Bilaspur districts of the Central Provinces, rice is sown broadcast, instead of by transplantation.

Excessive water used for rice cultivation in some parts.

Inferior cultivation of rice is sometimes due to the fact that water is allowed to stagnate on the fields; this is the case at Dacca, and I have also seen it at Ferozepore. There is little doubt that water is frequently shamefully wasted in rice cultivation, and, though plentiful water is requisite, stagnation is harmful to a crop. Mr. Nicholson says:—"The difference between a paddy (rice) field and a swamp is, "that, in the former, water is not allowed to stagnate on the "surface." He instances that as much as 12 feet depth of water is sometimes used in a single season for rice cultivation. It might be possible to effect improvement by a transference of practice in respect of the moderate use of water.

***Ráb* cultivation of rice.**

I mentioned in paragraph 131, when speaking of *ráb* cultivation, that in some parts of Bengal, where soil is poor and weeds predominate, a kind of *ráb* process is used, all manure being burnt before it is put on the land. In other parts this process is not employed. In Bombay the reasons for use or non-use of the *ráb* process are well understood, but this is not the case in Bengal, and it is quite possible that a transference of method in this respect may be followed by benefit in parts where the system is not known.

Early grazing of rice by cattle.

An actual instance of the adoption of transference of method was mentioned to me by Sir Edward Buck. The Burmese rice-growers often complained of the crop getting too tall, and of the seed dropping out, but when some Behar cultivators came and settled in Burma they introduced the practice of letting their cattle graze over the young rice, thus keeping it back. This practice was thereafter followed by the Burmese cultivators with success.

Possibility of improvement of rice cultivation in some parts.

Thus, even with a crop of such ancient cultivation as rice, there is, in some parts, room for improvement of its cultivation through the transference of the practice of one locality to another.

Improvement in cultivation of sugar-cane.

Different systems of sowing sugar-cane.

318. There is much that one district can learn from another in the better cultivation of Sugar-cane. The native method of sowing sugar-cane is to plough the land some 12 to 14 times, the plough going round and round the field and forming a fine seed-bed 4 or 5 inches deep. Next, the field is levelled, and the cuttings of seed-cane are scattered broadcast over the surface. The seed is then lightly covered over with soil. In consequence, the cane grows irregularly, and a jungle is formed; weeding cannot be properly done, and air and light cannot properly penetrate.

Advantage of Mauritius system.

The Mauritius system is to place the cuttings in holes about 9 inches deep, placed along rows 3½ feet to 4 feet apart, or else to lay the cane along channels or furrows in the bottom of which the manure is put, and the cane above it. The "hole" system is mostly used on undulating ground, but the "furrow" system is the best wherever irrigation is required. Thus, the "furrow" system is the one best suited to India. If the plan of sowing the seed-cane in furrows were to entirely replace that of simply levelling the ground and sowing the cane broadcast over the field, a very much increased yield of sugar would be the result. Messrs. Thomson and Mylne have clearly demonstrated at Beheea that this would be the case, and that the cane grows very much thicker if planted deeper. Nevertheless, the Behar cultivator, even on Messrs. Thomson and Mylne's own Estate, continues, with few exceptions, to adopt his old plan of broadcast sowing, and non-use of manure. It is noteworthy, however, that the iron sugar-mill is now universally employed.

Although in many parts, as in Behar, the old method of sowing is adhered to, yet in the best districts, and among the best classes of cultivators, the "furrow" system has made great advance, and it is recognised that it yields far better results; what is wanted is to make the practice universal.

Instances.

As a contrast to careless methods of sowing, I call to mind a practical demonstration which a cultivator at Máhim gave me, of the way in which sugar-cane is grown in the Thána district of Bombay. The entire process was carried out on a small scale before my eyes, and I could not but wonder at the great care displayed in every detail. The lines in which the cane was to be sown were pegged and marked out with strings;

the seed-cane was set at regular intervals, a stick being used to mark the respective distances apart; the soil was next covered over, and water was allowed to flow on gently, though not in excess; the manure (castor refuse) was put on, not broadcast, but in small handfuls around each plant, (the latter being supposed then to have grown); lastly, the leaves were tied round the stems, as the rainy season was represented to be coming on. Little wonder is it that the out-turn is so large and the crop so remunerative.

Again, as contrasts, I mention the following from Mr. Basu's Report on the Agriculture of Palamau: "The cultivation of sugar-cane is very "negligent, as now carried on; cuttings are sown at random and lightly "covered with soil; the fields are not hoed properly, and light and air do "not get in. This is very different to that of the central districts of Ben- "gal, where large kinds of cane, *e.g.*, *samsera*, are grown, and are planted "in furrows, the stems being wrapped up in leaves in the rainy season, "thus letting in light and air; here oil cake is used as manure, and the "fields are hoed. . . . . . So the Palamau *raiyat* gets his 25 maunds of "unrefined sugar (*gur*) per acre, while the *raiyat* of Burdwan or Hooghly "will obtain 60 maunds."

The Mauritius system of cultivating sugar-cane is practised around Calcutta, but is unknown in Bhagalpur and the greater part of the Patna Division. The cultivation of sugar-cane is much better in Burdwan than in Shahabad, though the manufacture of *gur* is, on the other hand, superior in the latter. At Hospet (Madras) sugar-cane is largely grown; it is always planted in furrows, these being split after about three months. At Meerut, Saharanpur, Hoshiarpur, and generally throughout the North-West Provinces and the Punjab, the "furrow" system of planting is adopted by the better cultivators.

Improvement in cultivation of the potato.

319. The cultivation of the Potato is carried on much better in some parts than in others. I find it stated that in Rawal Pindi:—

> "Potato cultivation is not good and leaves much room for improvement. "large and quick returns are obtained for a year or two and then fall off, "owing to want of careful husbandry."

In Lohardaga, potato cultivation is not carefully carried on, but in Hooghly and East Burdwan it is good.

Other instances of transference of method.

320. The sowing of "dry" (unirrigated) land in Northern Madras by means of a seed-drill has been mentioned, whereas this is unknown in Southern Madras (*see* paragraph 294).

In Tinnevelly cotton is not drilled, but it is very probable that if this were done much less weeding would be requisite.

Mr. Hill, Officiating Inspector General of Forests, in his Report on the Coorg Forests points out the benefit that would result from teaching the Kurubars of Coorg the plan of teak seed planting adopted by the Karens of Burma. At the commencement of the rains the seed is laid down in beds from which, as it begins to germinate, it is picked out and transferred to land on which rice, vegetables, &c., are grown. The teak seed is put in lines 9 feet apart, and 4 feet intervene between each seedling. The rice or other crop is reaped and the young teak plantation is left.

I might mention many other instances where benefit would follow the transference of cultivation methods, but the foregoing will fully suffice to make my point clear.

CONCLUSIONS.

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321. The differences which are met with in methods of cultivation throughout India are largely those belonging to the third class of differences set out in Chapter II., viz., those arising directly from *want of knowledge.* The variety of crops grown is, of course, bounded to a great extent by physical conditions, such as climate, soil, water, &c., but, as has been shown, it is in some degree also due to want of knowledge. Improvement in Agriculture will, as before, result from a modification of these differences. Such modification will be effected mainly by the transference of method from one district to another, and even from one country to another. The practice of other countries, as seen in the case of the many imported crops now common in India, as also in the planting of sugar-cane, may often be usefully adopted; so also may that of the better indigenous districts.

In the work of transference of method the people are likely to do but little or nothing, and the duty once more falls upon Government, and upon Agricultural Departments in particular.

The principal improvements that can be effected are: in demonstrating at Experimental Farms the benefits of selection and change of seed; in giving facilities for the supply, purchase, and distribution of good seed; in demonstrating the utility of new varieties of existing crops; in testing and introducing new crops; in investigating the diseases and attacks to which crops are subject; in transferring a better method of cultivation to a district where an inferior one prevails.

It is very clear that no work such as is contemplated in the foregoing suggestions, and more especially in the last-named, can possibly be carried out without a very thorough knowledge of existing practices. This knowledge, it seems to me, is still wanting, and can only be attained by a definite system of Agricultural Enquiry.

RECOMMENDATIONS.

RECOMMENDATIONS.

322. I recommend :—

The continuation of Experimental Enquiry at Government Farms in regard to selection and change of seed, growth of new varieties of crops and of crops altogether new, methods of cultivation, &c.

The establishment of Seed Farms under Provincial Agricultural Departments, for providing good seed for the various districts; and the giving of facilities and encouragement for the purchase of seed from these Farms by the cultivators.

The pursuit of the study of Diseases and injuries of crops.

The organisation of a system of Agricultural Enquiry, for the purpose of obtaining a thorough knowledge of present agricultural methods, and for the transference of better methods to districts where inferior ones prevail.

CHAPTER XIV.

AGRICULTURAL INDUSTRIES AND EXPORTS.

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323. In addition to the ordinary crops which the *raiyat* cultivates for his own use, there are some, such as tea, coffee, indigo, sugar, and tobacco, which undergo a process of manufacture before becoming marketable articles, and others, such as cotton and wheat, with which special considerations in the matter of export are bound up.

In the previous chapter *cultivation* only was dealt with, and suggestions were made as to how it might be improved. I propose here to treat of points in which I think an improvement, either in *manufacture* or in the conditions of *export*, may be effected.

Scope of this chapter.

I said then that it was no part of my duty to describe crops or cultivation, so it is not for me here to describe manufacturing processes, or to touch upon the relations of trade between India and other countries, or upon the varying elements which affect it.

During my tour I had the opportunity of seeing the industries connected with the utilisation of the above-named crops, and I shall briefly note any points which specially struck my attention as affording evidence of the possibility of improvement.

Sugar.

Sugar.

324. Sugar-cane is certainly one of the most profitable crops for the *raiyat* to grow. There is always a ready market for the manufactured sugar, and, generally speaking, the area of land under sugar-cane is not sufficient to meet the local demand for the unrefined sugar or *gur*, as it is termed. As a consequence of this, and of the high rates for transmission within the country itself, a great deal of sugar is imported from Mauritius.

In the Bombay Presidency it is estimated that, after deducting all expenses, a profit of from Rs. 30 to Rs. 40 per acre may be made by sugar-cane cultivation. The general out-turn of unrefined sugar (*gur*) may be put at one ton per acre.

Well suited to India.

Sugar-cane is a crop particularly well suited to India. The soil is adapted to it, and the climate is by no means unfavourable. Where irrigation is obtainable, cane can, as a rule, grow well, and yield a very rich return. India, indeed, in the matter of sugar production, ought to be an exporting rather than an importing country. It is well, therefore, to look at some of the reasons which have caused the present condition of things, and to consider whether they can be removed.

Improvement in production of sugar.

325. In the last chapter I have spoken of the cultivation of sugar-cane, and have shown that there is room for improvement in it. The improvement will consist principally in adopting the "furrow" system of planting (*see* paragraph 318). Beyond this, there are points connected with the manufacture of sugar from the expressed juice, which have been touched on under the head of "Implements" (*see* paragraph 288). If I were asked what had tended most to render the manufacture of sugar not as satisfactory as it might be, I should be inclined to say, "The little that is really known as to what influences the yield of sugar." On these points I will briefly touch.

Improvement in sowing.

326. In the first place, although it has been shown at Beheea that cane planted according to the Mauritius plan produces more sugar than when sown broadcast, more precise knowledge is required in regard to other parts of the country also, and the demonstration of the fact should be made clear to the people.

The yields from different varieties.

Next, whereas many different varieties of cane are grown, very little indeed is known as to the yield of respective varieties. In one district one kind of cane is in favour, in another a different kind. Sometimes a cane is required for eating purposes, sometimes one that will resist the attacks of white ants, or one that jackals will not destroy. But, though each may have its special merits, next to nothing is known of the actual amount of sugar that each will produce. Mr. F. M. Gill, of Nellikuppam (Madras), in a Report issued not long since, points out the great differences which exist in the juice of different varieties of cane. From his own experience he deduces the result that the variety of cane known in Trinidad as "Green Salangore" gives a better juice than any variety of cane grown in Barbadoes. This variety Mr. Gill believes to be the same as the ordinary Coimbatore cane. He therefore advocates the cultivation of this variety in preference to any other. Mr. Gill strongly urges the necessity for investigation into this branch of the sugar industry, and that careful analyses and records should be made and collected.

Influence of weather, soil water, and manure.

327. The influences of weather, soil, water, and manure, in determining the yield of sugar, are but little understood. The reason is not far to seek. It is, that no one has specially worked out the question for India. Here and there a few analyses have been made, and at one factory a chemist is regularly employed who has made some investigations, but the information needed is that from a much wider source, and embracing conditions not peculiar to one part of India alone. To give a single instance: in the neighbourhood of Poona, where cane is very extensively cultivated, and where the night-soil of the town is employed as a manurial agent, there is an idea that the "poudrette" (as the manure is called) gives a juice poor in crystallisable sugar. Whether this is actually the case or not still requires demonstration; at all events, it is given as one of the reasons why the sugar factory at Poona is not successful. The period of ripening is, it is known, affected by the use of certain manures, but the particular way in which they act is not understood. It has been noted already (*see* paragraph 99) that the native cultivator has a partiality for well water in preference to canal water, if both be obtainable, and that he sets a certain store upon water of a particular kind which is highly charged with soluble salts, and which he considers especially favourable to sugar-cane and tobacco crops. The use of earth impregnated with nitre, for putting round the stems of sugar-cane as a manure, has also been referred to (*see* paragraph 133).

Time of cutting cane.

328. Next, there is uncertainty as to the right time for cutting the cane. This can only be definitely arrived at by careful investigation and by the aid of chemical science. It is well known, however, that the measure of success attained depends much upon the time of cutting. If the cane be cut too early, the saccharine juice will be found not to be sufficiently developed, whereas, if left too long, some sugar will be transformed into fibre and other constituents. The desideratum is to take the cutting at the time of maximum development of sugar. The chemist at the Rosa Factory in the North-West Provinces has made analyses showing that the top joints of the cane contain no cane-sugar, even when nearly ripe, and that the common practice of reserving whole canes for "seed" is a wasteful one. The West Indian planter only uses the top of the cane for "seed," and this, though done in parts, ought to be done universally in India.

The "ratoon" system.

329. Another point on which there is very uncertain information is the extent to which the system of "ratoon" growing is a profitable one. In some parts, the cane, instead of being freshly planted each year, is allowed to stand over for a second, third, or even later season, and is then called "ratoon" cane. At Poona I saw such a crop of the sixth successive season, but the opinion is general in the district that "ratoon-growing" will pay for three years, but not longer. The advantages are, that much less labour is required, and that only half the amount of manure is used. On the other hand, there are the objections that after a time the land gets sticky, and cannot be worked properly; also that the new shoots spring out from "eyes" higher up the stem than they did when the cutting of seed-cane was deposited below the ground, and in this way roots grow out above the surface of the soil, giving the cane a less firm holding and less power of drawing upon the nourishment placed below it. I could not, however, obtain anything but expressions of general belief, and it will not be until the respective systems have been tried side by side, and the cultivation expenses, out-turn of sugar, and other items have been drawn up in a balance-sheet, that really reliable information can be given. Such work as this would be a most useful one for Agricultural Departments to undertake, and I would urge it being done, not only on Experimental Farms but on land in the actual occupation of cultivators. Where, as on an Experimental Farm, all labour is hired, cultivation expenses

Experiments should be made upon its value.

are very different to those which the *raiyat* would have to meet, and therefore it is of advantage to take land under ordinary cultivation, and to see exactly what it would cost the *raiyat* to carry out one or the other of two competing systems.

330. The point at which, perhaps, the greatest waste of sugar occurs is after the cane has been cut, and it is largely in consequence of imperfect management in the stages subsequent to the cutting that India is an importer of foreign sugar.

Transfer of cane to press, and rapidity of pressing.

Rapidity of transfer of the cut canes to the pressing machine, and rapid expression of the juice, are most essential, or the loss of crystallisable sugar through the setting-up of fermentation will be very great. There are few things which are capable of more rapid transformation into less valuable products than is sugar-cane juice, and every effort should be made to limit the action of fermentation. If the canes, after cutting, be left about, or have to be carted long distances, or if the pressing process be long delayed, loss of sugar must supervene. It is in obviating such difficulties as these that the Beheea iron mill has done so much good. It can be easily transported to the spot where the crop is grown, it presses the cane rapidly, and does not necessitate the repeated passing of the canes through it as the old native wooden mill did, nor the cutting up of the cane into the short lengths required by the "mortar and pestle" mill (*kolhu*). Both these elements in the native method of procedure promote acidification and consequent loss of sugar. Dr. Waldie and others have shown that about 10 per cent. more crystallisable sugar is found in the unrefined sugar (*gur*) obtained by the Beheea mill than in the product made by the native mills.

Advantage of Beheea mill.

331. Not only must there be rapidity in pressing, but also in transferring the expressed juice to the evaporating-pans, and in the boiling of the juice.

Evaporating-pans, and rapid boiling.

It is in this latter respect that a great improvement has of late been effected through the introduction of wide, shallow iron evaporating-pans in place of the narrow, deep, copper or even earthen pans that were universal before. The exposure of a large surface promotes rapid evaporation and gives less time for changes to take place.

Another essential to success is the removal of scum and of non-crystallisable bodies from the juice as it is being evaporated.

332. Perfect cleanliness of all vessels used in the manufacture is requisite for obtaining the maximum yield of sugar. The presence of any foreign material, dirt, &c., will speedily set up fermentation; so, too, will the use of any vessel with an imperfectly cleaned surface. Messrs. Thomson and Mylne pointed out to me that they had effected considerable improvement by inducing the native cultivators around them to collect the expressed juice in tin vessels, such as are used for holding paraffin, instead of in their earthen-

Necessity of cleanliness

ware vessels or *gharrahs*. The tin vessels can be readily purified by burning sulphur in them, and thus be kept sweet and clean, but the juice soaks into the porous earthenware pots and turns sour. Washing will not remove this, and the vessel is never sweet; the consequence is that, when fresh juice is poured in, the acidifying process is quickly set up, and a certain amount of crystallisable sugar is thereby lost. Captain Montgomery, in the Hoshiarpur Settlement Report, says :—

> "After pressing, a decided improvement might be effected in greater "cleanliness : the vessels which hold the juice are not cleaned as often as "they should be, and the juice therefore is very liable to acidification, "while the general disregard of the ordinary rules of cleanliness in the "sugar refineries is beyond description."

"Refining process."

333. In Coimbatore and many other parts it is usual to throw lime into the juice as it is being evaporated, in order to neutralise any acidity, but this is done in a quite haphazard way. In other cases no process of purifying the sugar is used. In Lohardaga and Palamau only the scum is removed, and there is no demand for sugar of superior quality.

The solid sugar called *gur* is the juice boiled down and allowed to cool into a mass. A liquid sugar called *rāb* is made by not boiling the juice as much as in making *gur*, and by clarifying it while it is being boiled; the juice is then left to cool in earthen vessels, and purified sugar may be made from it by a process of straining and crystallising-out which is conducted by the regular trader, though not by the cultivator. The process takes three to four months. The liquid sugar or *rāb* may also be purified at once by the "centrifugal drier," or "sugar-turbine," introduced by Messrs. Thomson and Mylne (*see* paragraph 292). The molasses drain away and leave the dry crystals. As much as 50 maunds (of 80 lbs. each) of *rāb* may be thus made into sugar in 10 hours.

The "centrifugal drier."

Proper desiccation and storage of the sugar after preparation by any of the above methods is necessary, and the "centrifugal drier" will be very useful where sugar is made in any quantity.

Native objection to refined sugar.

A difficulty in the way of improving the refining of sugar is that the demand for sugar of any kind is so great that the inferior qualities fetch a high price, and the better quality will not command sufficiently more to make the refining remunerative. A prejudice exists, too, against refined sugar, owing to the belief current among the Natives that it is purified by using the bones of animals.

Sugar Factories.

334. The establishment of central Sugar Factories has been urged as a means of increasing the sugar yield of the country. It has been pointed out that, while there are 2,500,000 acres under sugar-cane in India, the produce is only about one ton of sugar per acre, whereas in the West Indies it is about two tons per acre.

Cultivation in India and Mauritius compared.

Improvements in cultivation are, as I have mentioned, possible, but the Factory system, though it has been tried, has, with a few exceptions, been a failure. The reasons are various. One difficulty in growing sugar-cane is, that enough manure cannot be obtained, and dependence has also very often to be put on canals which afford uncertain supplies of water. Then, the rainfall is more regularly distributed in Mauritius than in India, and the produce will be affected accordingly. Again, sugar-cane is cultivated in India on a number of small patches, often some distance from one another, and not on large areas as in Mauritius; consequently there is considerable loss in cutting and carrying the canes any distance to a Factory, and the portable iron mill is found to be the most convenient machine to use. The high price asked for the raw material is another and true obstacle to the success of Factories. The local demand for *gur* is great, a good price is given for it, and there is an unwillingness to pay more for refined sugar. The working season in India is only about 75 days; in Mauritius, Demerara, &c., it is from 100 to 140 days. Lastly, only a few of the Factories are allowed to make rum from the molasses, and the prohibition, when exercised, destroys the profit of refining. The Factories at Poona and Baroda have failed from these reasons, but one in Kohlapur (a native State) pays because liberty is given to make rum. The Rosa Factory in the North-West Provinces pays fairly, I understand, and it is worthy of notice that the Company employ a chemist of their own.

Export and import of sugar.

335. In 1889–90 nineteen million rupees' worth of sugar was imported into India, chiefly from Mauritius, whilst nine million rupees' worth of unrefined sugar was exported, chiefly from Madras. Import is mainly confined to the Bombay side, and here Mauritius sugar has quite driven out the North-West Provinces sugar, owing to the cost of transit within India being so great. On the other hand, export takes place on the Calcutta side and from Madras. The question naturally suggests itself; Why do not Madras and Bengal supply Bombay?

Date-sugar.

Sugar is, in a few cases, derived from other sources than the sugar-cane; for instance, the Date-palm (*Phœnix dactylifera*) is sometimes used for sugar manufacture in the Lower Provinces of Bengal. Its use is, however, declining very much.

Extension of cultivation of sugar-cane.

336. There is no doubt that a much larger area of land could be put under sugar-cane. More manure would be needed, and perhaps more water facilities also. Still, it is noteworthy that, around Beheea, when Messrs. Thomson and Mylne first came to it, there used to be only 1 per cent. of the cultivation under sugar-cane, and now there is 10 per cent.

Mr. Nicholson points out that in Coimbatore there are tens of thousands of acres of wet land on which Rs. 20 an acre are spent in order to grow a crop of food grain worth Rs 40, whereas on the same land rich crops like sugar-cane and plantains, worth Rs. 150 an acre, might grow splendidly. Rich merchants, however, buy the land as an investment, and hand it over to poor tenants for cultivation; these latter cannot put a single rupee into the land, but are obliged to utilise it for growing grain crops to feed themselves. Mr. Nicholson estimates the profit on the growing of sugar-cane to be from Rs. 75 to Rs. 125 per acre, or, if made into sugar, from Rs. 85 to Rs. 105 per acre.

Mr. Sen, in his Report on the Agriculture of Dacca, says:—

> "The extent of land capable of growing sugar-cane is probably greater "than in any part of Behar and Lower Bengal, and the supply of sugar-"cane for local consumption comes from places so far distant as Ghazipur "and Benares (both in the North-West Provinces). The soil is fertile, "but the cultivators are lazy and devoid of enterprise. If properly "utilised, the land can produce sufficient sugar to supply the demands of "the whole of Bengal, but the cultivation of sugar-cane is at present "extremely limited."

Sugar-cane used to be extensively cultivated in the Central Provinces. The juice was boiled over wood fires, and large areas were denuded for the purpose of getting the firewood. Now, owing to the scarcity of firewood, the cultivation of sugar-cane has been largely given up. Mr. Fuller, on coming here from the North-West Provinces, introduced the practice common in Meerut and Rohilkhund, and showed that the juice could be boiled quite well by using the *megass* or spent cane after it has passed through the rollers, and that firewood could thus be dispensed with.

This is a good instance of improvement by transference of practice.

Need for chemist.

337. In the various points upon which I have touched I have, I think, made it abundantly clear that, in the cultivation and manufacture of sugar, there is sufficient work to call for the employment of a chemist for the purposes of that industry alone. Occasional assistance in the numerous questions awaiting decision may be rendered by a Government chemist temporarily giving his attention to such matters, but the subject is one really large enough to justify the telling-off of a man specially for this work. If a single Factory finds, as I am assured that it does, that it must have its own chemist, how much more reason is there for the deputing of a man to work, from the chemical side, at the questions affecting an industry of so much concern to Indian agriculture.

Duty of Agricultural Departments.

A considerable duty also rests on Agricultural Departments to collect precise information as to the cost of cultivation, the out-turn, and the merits of different implements and methods of manufacture, so that the most profitable one may be introduced and be generally practised.

Cotton.

Cotton.

338. Cotton, like sugar-cane, is a very profitable crop for the *raiyat* to grow. The actual cultivation of it is thoroughly well understood, and I am not aware of any suggestion that can be made for improvement in this respect. There is, however, a great deal of information to be gathered in regard to the respective yields of different varieties, and towards ascertaining which is the most profitable one to cultivate.

Cotton is generally a single year's crop, but perennial varieties are occasionally grown which are left for a second or a third year. I saw perennial cotton growing at Ahmedadad and at Avenashi (Coimbatore). The indigenous varieties now generally cultivated give a short-stapled, hard cotton, although finer and longer-stapled varieties are still cultivated in some parts of Berar, in Broach, and elsewhere. American varieties of cotton were introduced about 60 years ago, and have been acclimatised, principally at Dhárwar; they yield a fine and long fibre. For the last 20 years there has been a steady deterioration in the quality of the cotton exported from India, and the long-stapled varieties, which, under the special names, "Oomras," "Broach," "Dhárwars," &c., had acquired special favour in the Liverpool market, have been subject to an increasing and now enormous amount of adulteration with the inferior, shorter-stapled kinds, so that the significance of the old names has now almost disappeared, and complaints as to the inferiority of Indian cotton have been very great. The cotton most largely used in this way is the *Vilayati* or *Varadi* cotton of Khándesh. The cotton grown in Bengal, the North-West Provinces, the Punjab, Rájputana, and Central India generally, is known as "Bengals;" that from Madras and Western India generally, as "Westerns."

Acclimatisation of cotton.

"Mixing" of cotton.

339. Many efforts have been made, and even Government legislation has been tried, in order to keep pure the finer qualities of cotton, and to prevent the increased growing of the coarser native kinds. But all these efforts have failed, and at the present time the cultivation of the indigenous varieties is more extensive than ever. The reasons are, briefly, that the country cotton is a better-yielding variety, it is earlier, and more hardy than the long-stapled kinds; besides, it commands a good price, the crop pays the *raiyat* well to grow, and there is a ready demand for every bale that is grown. The *raiyat*, therefore (and, as it seems to me, wisely), concludes that he is justified in continuing to cultivate the coarser kinds, and he does not care to run the risk of growing a smaller-yielding and less certain crop, besides having to wait longer for it, and in the end getting but little more return for it. A quick return means, to the *raiyat*, that he can the sooner repay the loan he has obtained for the seed and the cultivation. The general opinion is that it is useless to interfere by legislation, and that unless it can be shown to the *raiyat* that he will get more for growing fine cotton than he does now, and more than will cover the risk he runs in the smaller and less certain crop, he will continue to grow the country cotton, and legislation will fail, as it has done before, to prevent him from getting and sowing the seed which he knows will succeed. As long, too, as there is the ready

Attempts to improve cotton.

demand which exists for the country cotton, and so long as merchants will not give higher prices for better kinds, the supply of country cotton will be maintained. But if the complaints made against Indian cotton proved to be so well founded that the merchants had to stop purchasing the cotton, then, I believe, the *raiyat* would very quickly alter his practice and grow the finer kinds. In this matter, as in many others, the cultivator would show himself quite alive to his own interests, and he may be very well trusted to do what pays him best.

The preservation of better varieties.

340. There may, however, be some fear that if there were a sudden demand for finer cotton the *raiyat* would not have the seed for growing the crop. Therefore, I regard with favour a proposal made by Mr. Ozanne, to grow and to perpetuate a certain quantity of pure seed of some of the better varieties, such as *bani* and *jari*, which are still known in Berar.

It would, further, appear very desirable to have some recognised trade-mark description for the various kinds of cotton grown. At present there is no protection for any of the admittedly finer varieties, although merchants might be willing to pay a higher price for them.

The misfortune as regards the cultivator of the better kinds of cotton is, not only that there is no protection afforded to him whereby a certain name and better price would be secured for his cotton, but that, through the system of obtaining seed-cotton by advances on it from the grain merchant, a pure seed is not obtained for re-sowing. The cotton pickers are always paid *in kind*, receiving so much seed in return for their labour; they take the seed in small lots to the grain merchant, who mixes all the seed together, and the cultivator buys back, not his pure seed, but a *mixed* lot. Thus the purity of a variety becomes lost.

Cotton Presses.

The Cotton Presses which are now distributed over the country are, it would appear, responsible for a part of the systematic "mixing" which goes on. The cotton is brought in, cleaned, and packed by the Presses for transmission to Bombay and other ports for shipment. A Cotton Press which I saw at Jeypore had paid all its expenses in the first three years of its existence. The "mixing" of cotton which goes on up-country is due, in great measure, to the fact that the merchants at Bombay and other ports, instead of purchasing direct, leave the execution of their commissions to native local traders, in whose hands is, therefore, the entire manipulation of the cotton. If the merchants were to go up-country themselves and purchase direct from the producers, a better state of things would prevail.

"Mixing" of cotton.

It would be a mistake, however, to suppose that all the "mixing" of cotton goes on up-country. On the contrary, the European merchant is greatly to blame, and very much of the "mixing" goes on at the ports of shipment, under the eye of the heads of European firms.

The remedy rest with the trade.

341. The whole question of the adulteration of cotton is one the remedy for which seems to rest rather with the trade than with agriculture. If there were a demand for long-stapled cotton, and if the trade were willing to give more for it, the cultivator would soon grow it; but so long as the demand for cheap cotton is so great, no change can be made, and it would be unwise to interfere with trade by legislation, or to try to oblige the *raiyat* to grow only certain varieties of cotton.

Export of cotton and cotton seed.

342. Dr. Watt estimates the total annual production of cotton in India at 9,200,000 cwt., of which, 3,500,000 cwt. are consumed in Indian mills, and 5,700,000 cwt. are exported, principally to the United Kingdom.

I have spoken of cotton seed as a food for cattle, and have mentioned that it is but little exported (*see* paragraph 127). Dr. Watt has called my attention to the fact that, reckoning from the cotton produced, and after deducting what seed is used for home consumption and for sowing again, there ought to be fully 600,000 tons of cotton seed available annually for export.

Indigo.

Indigo.

343. The cultivation of indigo is, perhaps more than that of any other crop, beset with considerations which are rather of a political than of a strictly agricultural character. It would be foreign to the objects of my Report were I, with my limited experience, to enter into the discussion of matters which call for a wide knowledge of the political relations of planter, *zemindar*, and *raiyat*, as well as of the past and present condition of the people in the indigo-growing districts.

These points, all important though they be in their bearing upon the indigo industry, must be left to others to deal with. I shall, as I have done before, confine my remarks to a few matters which came under my notice when visiting the indigo districts of Behar.

Its cultivation.

344. Indigo is grown under several different systems, the merits of which I will not discuss, but, generally speaking, the *raiyat* covenants with the European planter to grow indigo for him over a certain proportion of his holding. There is no stipulation as to how the land thus set aside shall have been previously cultivated. The planter has, in addition, a certain amount of land around his factory which he cultivates himself, growing on it principally indigo, with an occasional change to oats or barley, or else sugar-cane, *juár* (*chari*), maize or some other fodder-crop for feeding cattle (*see* paragraph 236).

The cultivation of indigo has been very greatly improved by the European planter, and the native growers have to some extent followed the example set them. I have noted in previous chapters (*see* paragraphs 55, 278, 294) how great is the care exercised in tilling the soil, in obtaining a fine even surface, in preventing any loss of moisture, and in breaking up any crust that forms after rain has fallen. I have pointed out also that selection of seed is carefully attended to (*see* paragraph 308), and that imported or "improved" implements have an opportunity of being usefully employed in indigo cultivation (*see* paragraph 281.) On the indigo estates or "concerns," as they are called, there is a large area to be sown, and it is all important to get this done quickly and just at the right time. Hence the indigo planter uses a drill which will sow, not one, but several rows at a time, and he uses a large number of these drills.

Continuous cropping with indigo.

345. Whenever it is possible, an indigo crop is taken on the home land, but occasionally a change in the cropping is made. This however, can hardly be termed "rotation;" it is merely a "rest" to the land from growing indigo, and is resorted to whenever the crop shows any signs of failing. During my tour, land was pointed out to me which had been under indigo for as much as forty years with only a very occasional change of crop. The capability of the soil thus to grow indigo successively is, in my opinion, closely bound up with considerations which have been quite recently brought to light by scientific investigation. It has been shown that certain plants of the Natural Order *Leguminosæ* have the power of assimilating indirectly the nitrogen of the atmosphere. This power is exercised, not by direct inspiration through the leaves, but by the medium of particular "nodules" which form upon the rootlets of the plant, and enable the plant to utilise the nitrogen supplied from the atmosphere (*see* paragraph 60).

Possible explanation.

The indigo plant (*Indigofera tinctoria*) belongs to the Natural Order *Leguminosæ*, and, although scientific investigation has not, as yet, been specially directed to it, I have little doubt that it will be found to possess properties similar to those already established in the case of other *Leguminosæ* that have been studied. Presuming this to be the case, we may have in this the explanation of the continued cropping with indigo that is such a remarkable feature in India. It is not, I should point out, a parallel case to that of continuous corn-growing, the possibility of which has been clearly shown in England; nor yet is it like the continuous cultivation of such crops as sugar-cane, coffee, tea, &c., in the West Indies and elsewhere. In these cases the continuity is maintained by the heavy application of manures which supply the demands of the plant, and accordingly, if there be manure enough, and of a suitable nature, rotation may, within limits, be dispensed with. Thus, at Rothamsted, Messrs. Lawes and Gilbert have grown wheat and barley continuously for 50 years without change, by the aid of artificial manures. At Woburn, I myself have under observation similar experiments where these corn crops have been sown year after year for 16 successive seasons, and still continue to yield an undiminished produce. The limit, so far as the practical farmer is concerned, is that of the expense and trouble of keeping the land clean, and of freeing it from the weeds which are the invariable concomitant of these crops. These can best be got

Comparison with continuous corn-cropping.

Practical limits.

rid of by introducing a change of crop, and by growing one the habits and cultivation of which differ from those of the crop which has preceded it. In this sense a root crop may be termed a "cleaning" crop.

Manuring for indigo.

But though the case of indigo is analogous in the respect of requiring an occasional "cleaning," it is very different in that of manurial treatment. Broadly, it may be said that the only manure for indigo is indigo itself, in the form of the refuse indigo twigs and leaves, termed *seet*, which are removed from the vats after steeping has been done. Artificial manures have made no way in India, and where they have been tried for indigo they have not clearly shown any compensating benefit. Even with simpler manures, such as lime, gypsum, nitre, &c., there is uncertainty as to their efficacy. *Seet*, on the other hand, is known to be beneficial, though it has yet to be established *how* it acts, whether by virtue of the nitrogen which it supplies, or on account of the vegetable matter which it returns to the soil, or possibly even by its physical effects and moisture-holding properties. What the planter does complain of is, that he has not as much *seet* to put on the land as he would like.

Indigo cultivation, accordingly, is not an illustration of rotation being dispensed with by means of heavy manuring, but the explanation of its continuation may possibly be found in the power which it shares with some others of the *Leguminosæ*, of assimilating atmospheric nitrogen. This opens up a very interesting field of investigation, for which India affords special opportunities.

Change of cropping.

346. While indigo may thus be, and is, taken year after year, it is known that a change of cropping is occasionally desirable or even necessary. This is termed a "rest" for the land. Similar, though more serious in result if not freely practised, is the change required with clover-cropping in England, the land being rendered "clover sick," as it is termed, if clover be too often repeated during the course of a rotation. Miss Ormerod, lately Consulting Entomologist to the Royal Agricultural Society, has shown that, concurrent with, even if not causative of, this "clover sickness," is the presence of a destructive eel-worm (*Tylenchus devastatrix*), whose extermination is best effected by "starving it out;" in other words, by growing in place of the clover some crop on which the *Tylenchus* will not thrive, and in not repeating clover until the pest has died out.

Insect ravages.

Similarly, the indigo crop has its own particular pests, although their ravages are not so general as to prohibit the cultivation of the crop. Caterpillars and a kind of cricket called *zirwah*, which burrows in the ground, are its principal enemies.

A change of cropping is the most effectual means of getting rid of the pests, both insect and vegetable, which attack the plant, and which are more or less fostered by the continuance of one and the same crop upon the land. A change in culti-

Advantage of change of cropping.

vation is also beneficial to the soil, and the growing of a crop different in its plant-requirements to the preceding one enables dormant or non-utilised constituents in the soil to be made use of to the advantage of the new crop. I believe that change of cropping might be usefully followed in indigo cultivation to a much greater extent than is now the case, and this without expenditure of more manure. What has told in the past against the practice is the anxiety of the planter to get his money as quickly as possible out of the indigo cultivation, and therefore to put as great a breadth of land in indigo as he can.

Selection and change of seed.

347. Care is shown in the selection of seed, for in this respect the European planter does not follow the Native. There are English merchants at Cawnpore and elsewhere who make it their business to select and sell good seed to the planter, and the planter in turn is very particular to get a change of seed.

Unsolved questions as to cultivation.
Thick or thin seeding.
Manuring.

348. There is, however, considerable uncertainty as to whether thick-seeding or thin-seeding is the better. Then, uncertainty exists as to manuring, except in the value attached to the refuse indigo plant or *seet*. The *seet* water, or water run off from the settling-tanks in which the finely divided indigo deposits itself, is sometimes used on the land with a manurial object in view, but it is more often allowed to run to waste, as being worthless. Its value has yet to be demonstrated, and I could form no definite opinion on the point without chemical examination and experimental trial. There is much difference of opinion, again, as to whether *seet* should be spread on the land thickly or thinly. Each planter has his own idea of what is best, and he holds to that. Another disputed question is, when the *seet* should be put on. Some planters cart it out fresh, straight away from the steeping-vats, others prefer to let it rot and to apply it when old.

Neglect of experimental enquiry in indigo cultivation.

I have been on estates where it is the practice to collect bones, to grind them in a mill, and use them as manure; more often they are collected, broken and bagged for export. Thus, even by the European planter, the value of bones has not been established, or, rather, a better return can be got by the sale of the bones. I have been with a planter whose belief in the sulphate of lime (gypsum) and other sulphates was almost unbounded, also with another who thought that nitre was what was wanted for indigo, whilst many more whom I met ridiculed equally either idea. But I never saw anywhere what I would call a "comparative trial," conducted on a level uniform piece of land, with portions marked off, one cultivated in one way and another in a different way. Suppose, for example, one plot thickly sown, the adjoining one thinly; one manured with *seet* thickly spread, the other with a thin dressing only; one on which *seet water* had been poured, the other with the same volume of ordinary water only; one manured with fresh *seet*, the other with old *seet*; one manured with bones or with nitre, or else gypsum, and a corresponding one without. These might all form useful experimental trials, and I might easily multiply them, but enough has been said to show what scope there is for enquiry in connection with the cultivation of the indigo crop. The most I could hear from any planter was that he had tried this or that plan one year, but he could not see any benefit from it, and so did not repeat the trial. But I cannot regard these as "comparative trials." An experiment, to be a real one, must be a test of one practice against another, carried on side by side, under as similar conditions as possible, and it may have to be repeated, and ought to be repeated, before a definite conclusion can be come to. It is not that a large area is required, or that the risk of heavy outlay is incurred. For an experimental area, an acre, or even half an acre of land would be ample, and if every field had such an area, and if it were made the "learning school" for future extension of one or the other practice, great benefit would result, and an answer be given to the many questions awaiting solution. But the planter prefers to put a whole large area under a so-called "experiment" and to incur risk and expense in giving it a thin or a heavy dressing of *seet,* of bones, or other manure, without having previously ascertained by any trial on a small and inexpensive scale whether it is likely to succeed or not. If only planters would adopt the simple plan of making "comparative trials" *on a small scale* at first, they would gain knowledge which would repay the trouble over and over again when they came to applying the result to the larger area. But what happens is, that when the crop is ready to cut, all that the planter thinks about is to get it carted home, and to put it in the vats as soon as possible, and so the "experiment" has to go to the wall. I know only too well that this is the general fate of experiments in England as well as in India, and the indigo planter in no way differs from the average good English farmer, who, though he may be induced to start and to watch an experiment while it is in progress, yet fails at the last by not reaping the produce separately and weighing it, but allows "estimate" or "guess-work" to take the place of ascertained "fact," and recorded result. I know that there are difficulties to contend with, and that the separate reaping and weighing at harvest involve trouble which comes at the most awkward time, but I am equally certain that until planters will go to the trouble of seeking truth in the way which I have indicated, no definite progress will be made, nor the many questions affecting this important industry be decided.

Unsolved problems in the manufacture of indigo.

349. If the remarks which I have made apply to the cultivation, similar ones might be made with even more force upon the *manufacture* of Indigo. It is allowed on all sides, even by the planters themselves, that the manufacture, as at present conducted, is a mere "rule of thumb" one, and utterly unscientific in character. So, indeed, I found it to be, though it is no easy matter to say off-hand how it should be altered. I saw enough to warrant me in saying that there is ample scope for improvement, for instance, in the replacement of a "rule of thumb" method by a strictly scientific one, one, that is, in which the details of every step are thoroughly understood. But, at the same time, I could see that it would not be done by anyone coming as I did and simply throwing out a suggestion or two; but that it would require the aid of someone who had made a thorough investigation of the whole subject from the chemical side, and who could study each detail, ascertaining exactly what changes take place at each step, and then following these throughout until the final stage is reached. The same difficulty which attends experiment in the field accompanies experiment in the factory. There is the anxiety to get on as quickly as possible, the impossibility of checking any process when in actual operation and the preference to continue in known ways rather than to run the risk of failure with new ones. And so, I fear, it will always be, until someone lays himself out to carefully work at the subject, and to experimentalise, so that the changes which take place and the conditions which regulate these changes may be fully understood. The planter is not a man naturally of a scientific turn of mind, and he does not care to experiment in directions not understood by him. The same causes, I regret to say, make him, not unfrequently, the victim of the pretensions or persuasions of men who, with some smattering, perhaps, of scientific knowledge, induce him to adopt this or that patented method of their own, assuring him that thereby he will distance his brother-planters in the quantity and quality of his out-turn. It is surprising what a readiness is shown by the planters to take up and to work for a time the invention of some adventuring so-called "chemist," although previous efforts of the latter may be known to have proved disastrous failures. There is always someone ready to take on the new "patent process," and to embark upon it, in the hope that, out of the many plans that have been put forward, one at least must turn out a success, and that it will be his good fortune to secure that one chance out of the hundred.

'Patents' in indigo manufacture.

If planters, instead of endeavouring to gain an advantage one over the other, would only combine together to have the whole subject carefully worked out by a man of eminent scientific standing and of known integrity, the result might be attended with enormous benefit to the whole of the planting community, and the enquiry could be carried out at an infinitely lower cost than is now expended by individual planters or trading firms in abortive attempts to secure an advantage over their competitors.

Packing of bundles in vats.

350. To take some of the points in dispute. It is still unknown which is the best way to pack the bundles of indigo plant in the steeping-vats; whether, for instance, they should be tightly or loosely packed. Some planters support one view, others the opposite, while many maintain that the manner of packing is quite immaterial. The kind of water which it is advisable to use is another matter for discussion. It is argued' though quite empirically, that the white streaks often found running through the blocks of manufactured indigo are the consequence of a hard water being used, that is, one containing a quantity of lime salts. To obviate this difficulty, some planters have employed a process for softening the water before it is run into the steeping-vats. But there is no satisfactory evidence as to whether this is essential or even desirable. The superior quality of the "mark" of a particular factory is frequently put down to the kind of water used, and there is a general agreement that soft water is preferable to hard, and that muddy, stagnant, or foul water is prejudicial to the production of a good quality of indigo. I have little doubt that the kind of water used is of material importance, for soft and hard waters have very different extractive powers. But it has still to be determined whether the matters capable of being removed from the indigo plant by the one kind of water and not by the other are conducive to a larger or better out-turn, or otherwise.

Kind of water used.

The length of time which steeping should occupy is another debated point. Some say that the best colour is got by short steeping, and that though the quantity obtained may be less, the best paying result is obtainable in this way. Others will steep for nine to ten hours, or even for as long as twelve and thirteen hours.

Duration of steeping.

351. Over the question as to whether the cut plant should be steeped in water alone, or with some chemical re-agent, a great deal of speculation and a great deal of money have been expended, and so far with little result. It is this stage which has been the principal field for the ingenuity of the "inventor." The use of nitre, ammonia, alum, carbolic acid, caustic soda, and other materials has been brought forward, and each plan finds some planter or other who is willing to take it up from time to time, although as to what the action of the added chemical is, there is complete ignorance.

The use of chemicals.

352. When we pass on to consider the "beating" process, the want of harmony between practice and theory is more than ever apparent. The accepted ideas of each are indeed almost diametrically opposed. What is effected by "beating" the indigo-containing liquid after it has been run off from the steeping-vats is very far from being known, and until some one of high chemical attainments can work at the subject, not simply in the laboratory, but also in conjuction with the actual manufacturing process, the real solution of the question will be very distant. The entire manufacture, from the beginning to the end, is one which should be intensely scientific, and should proceed on the most definite lines, instead of which it is, as I have described it, a "rule of thumb" procedure. To take a single instance. The time at which "beating" should cease is determined by a very rough test, the object of which is

The "beating" process.

to see whether the indigo has been separated out from the water. If the finely-divided indigo settles down quickly and leaves no blue solution above, the "beating" is considered complete. This may serve as a rough indication, but is not more, and it ought to be replaced by a chemical test which would indicate more certainly whether a quantity of indigo was being run to waste or not.

The "boiling" process.

353. After the indigo has deposited itself in the "beating-vat" and the supernatant liquid has been run off, the finely-divided indigo or "fecula" is transferred to the boiling-vats. But, here, again, difference of opinion exists as to whether it should be boiled once only, or twice, and also as to the temperature which it is best to employ in boiling.

The practical and the chemical views compared.

354. Dr. Watt, in the able article which he has written on indigo in the "Dictionary of Economic Products," reviews fully the bearing of scientific investigation upon the manufacturing process, and emphasises the failure to apply the former to the latter. The main question, as to what "beating" effects, resolves itself into that of whether *oxidation* is produced in the beating-vat, or whether the change is one of a purely *mechanical* nature.

The colouring matter contained in the indigo plant is a soluble glucoside termed *indican*, which, on maceration of the plant with water, is converted into *indigo-blue*, and this latter, on fermentation, is reduced to *indigo-white*.

The view of the practical man is that when the plant is steeped in the vat, fermentation takes place, *indigo-white* is produced, and in the "beating process" this is oxidised back again to *indigo-blue*. Consequently, several patents have been introduced with the object of facilitating fermentation and rapid oxidation, and they consist in the addition of substances, such as nitre, alkalies, &c., to the steeping-vat, or to the beating-vat. If oxidation is effected by the "beating," the liquid as it enters the beating-vat from the steeping-vat must be *indigo-white*, and this, by the oxidation, becomes converted into *indigo-blue*. But if the liquid as it enters the beating-vat is already finely-divided *indigo-blue*, there can be no use in putting oxidising materials into the beating-vat, and the change produced by the "beating" must be a purely mechanical one.

The chemist who has worked most at this subject is Schunck, in Germany, and he has clearly shown that oxygen is not necessary either for the decomposition of the colouring matter *indican* in the plant, nor for the formation of *indigo-blue*. Therefore it is hard to see what good purpose the addition of oxidising agents can effect, and possibly it may do harm. The further investigations of chemical science have led to the conclusion that fermentation is not required at all, but that by simply macerating the plant with water or with a little acid, *indican* is extracted and is decomposed at once into *indigo-blue* and an indigo-sugar, called *indiglucin*. What is needed, therefore, is, not to assist, but to *prevent* fermentation the effect of which would be to decompose the *indigo-blue* into *indigo-white*, and necessitate its re-oxidation to *indigo-blue*. The process of manufacture as now generally carried out would appear to be this latter one, and to comprise really three stages, viz., the formation of *indigo-blue*, the reduction to *indigo-white*, and the re-conversion to *indigo-blue*, whereas the chemical process would be a single one, viz., the formation of *indigo-blue*, and its retention in this form by *arresting* fermentation.

The necessity for applying chemical science to the manfacture of indigo.

355. It would be of little use were I to enter further into the discussion of what takes place, but I have said sufficient to show that at almost every stage of the manufacturing process there is an absence of any definite knowledge. This knowledge can only be obtained by the application of chemical science to the manufacture. In hardly any other branch of industry where chemical processes play an important part is there such neglect to obtain the scientific help that is required for the proper working of the industry. But, in the case of indigo, the old ways are kept to, and no advance is made. Meantime, chemists are busy in England, Germany, and elsewhere, in working out methods for successfully replacing the natural product by artificial means, just as they have done in the case of cochineal, madder, and other dyes. I regard it merely as a matter of time when this will be successfully done, and it can only be postponed if those who are engaged in the indigo industry will make use of the very best scientific assistance they can obtain, for the purpose of putting the manufacture upon a rational and scientific basis. If the indigo planters would but combine together to engage a chemist of high standing who would take up this investigation in a thorough manner, it would be the very wisest thing they could do; otherwise they must be content to see the prosperity of the industry gradually decrease.

Unsatisfactory conditions of indigo cultivation.

356. Undoubtedly there are improvements which can be effected in connection with the system under which indigo is cultivated.

Under the *assamiwar* system (the one most generally adopted) the planter takes a lease from the *zemindar*, and the *raiyat* is virtually a tenant of the planter, but is obliged to put a certain proportion of his holding under indigo each year for sale to the planter.

It must be acknowledged that indigo-growing under these conditions is not altogether a voluntary system on the part of the *raiyat*. He does not look on the indigo crop as he does on a food crop; there is not the same inducement for him to grow a good crop, since he is paid one of two rates, either for a full-crop or for a half-crop, and not according to the actual yield. The *raiyat's* constant endeavour is, therefore, to give his worst land for growing indigo, whilst the planter's aim is to get the best land.

On the other hand, the planter has his own difficulties. For instance, he has a large capital invested in his manufacturing plant, while he is himself placed to a great extent in the *zemindar's* hands in regard to the continuance of his lease; he has to meet the difficulty of procuring sufficient land for growing the crop under the system generally prevalent, whilst were he to adopt that of purchasing the plant from the *raiyat* by the bundle (the *khuski* system) he might not get sufficient crop.

The prevailing system, it is right to say, is not a creation of the English planter; he found it existing when he came, and has simply continued it.

Lastly, all alike, whether planter, *zemindar*, or *raiyat*, suffer from the non-existence of a proper Record of Rights, in which the areas of holdings and the rents charged should be clearly defined.

Tea.

Tea.

357. I took the opportunity afforded by my travels, of seeing something of tea cultivation both in the Neilgherries and at Darjeeling.

This industry, like that of indigo, is one in which empirical rules take, to a great extent, the place of ascertained and clearly defined truths, and both in the growing of the crop and in the manipulation of the tea, there is much still to be learnt. My visits were of too hurried a nature to enable me to do more than get a general insight into some of the questions which are waiting for solution.

Unsettled points in tea cultivation.

358. There appears to be still a good deal of ignorance as to the elevation best suited to tea cultivation. Thus, in the Neilgherries, tea is grown as high as 7,300 feet above sea-level, while in the Ouchterlony valley the elevation is 3,500 feet only. In the Darjeeling districts similar wide variations are found.

Then, in respect of the soil, little is known as to its requirements. In the Neilgherries, for instance, there is good reason to believe that a deficiency of lime, if not of available potash also, has had to do with the decadence of tea cultivation there. On almost all sides there is but little known about manures, even about those which are available, such as oil cake and bones; the different oil cakes are classed together just as if they were the same and of equal value; it has not been established whether bones are useful, whether green-manuring is advantageous, and still less on which lands the systems should be or need not be employed. The influence of particular fertilisers, such as nitre or other potash-containing manures, or else of phosphatic or nitrogenous manures, upon the quantity and quality of the tea is not definitely known. In regard even to tillage there are questions, for example, as to what depth of soil should be turned up, whether the land should be left in clods or be tilled finely, how far drainage is requisite, &c.

Unsettled points in tea manufacture.

359. The same kind of difficulties are met with in the manufacture of tea; and the delicate processes of drying, withering, rolling, fermenting, firing, &c., are carried on with an almost entire ignorance of the chemical changes which take place at each stage, and without the power of controlling them in any way. By long practical experience a great deal of knowledge has been gathered by skilful manipulators, and the changes of appearance in the leaf at the different stages are closely watched and taken as a guide, but this is very different to knowing exactly what does take place, and how to regulate each operation, so as to produce the best result.

Insect and other ravages.

360. Another field of enquiry consists in the study of the insect and other ravages to which the tea plant is exposed, and in devising means for combating them.

The "red spider" (*Tetranychus bisculatus*) and the "tea bug" (*Helopeltis theiovora*) are the main insect pests, and, as yet, no successful way of preventing their attacks has been found. Mr. Wood-Mason in particular has given a great deal of attention to the study of the work of these insects. At Darjeeling I found that "sulphuring" was largely made use of to guard against "red spider," but it was an expensive process, costing quite Rs. 20 an acre.

Appointment of chemist by Indian Tea Association.

361. It is an acknowledgment of the importance of scientific inquiry in connection with the cultivation and manufacture of tea, that the Indian Tea Association have commenced a definite line of investigation, and have secured an analytical chemist of their own. Mr. Bamber was originally appointed in October 1890 for a term of 1½ years, and has already presented his report of the progress made during the first year; this has had to do with enquiries as to the soils, cultivation, and manuring of the tea plant. It is now proposed to continue them for one year more, but more specially to devote investigation to the manufacture of tea.

The insufficiency of the enquiry.

I am far from saying that an enquiry lasting over 2½ years will not be productive of some good, but I am decidedly of opinion that the time is far too short to allow of the solution of any but a few of the many problems which have been sketched outfor decision. It seems a pity that an enquiry affecting an industry of such importance, and representing so much capital as the tea trade possesses, should be limited to so short a term.

Proper method of enquiry.

The first thing that a man coming out to take up a work of this nature must do, is, not to make discoveries off-hand, or to invent theories, but to make himself thoroughly conversant with what has been done before, both in the cultivation and in the manufacture. It is only after this that he can be expected to usefully apply his scientific knowledge to the actual details. This is a work, not of a year or two, but of several years, and it necessarily involves patient work and patient waiting, though sooner or later I am sure that the industry will reap the benefit, as others have done which have made use of the application of science to practice.

Coffee.

Coffee.

362. My tour took me through some of the coffee-growing districts of Coorg and Mysore, and, besides meeting a number of planters, I stayed some time with Mr. R. H. Elliot on his coffee estate at Bartchinhulla, Munjerabad, where I had a good opportunity of learning about this industry.

As compared with tea, the industry is a much simpler one, for the manufacture does not involve the careful manipulation that is requisite with tea; but the actual cultivation is a matter of equal importance in each case.

Problems in coffee cultivation

363. I may briefly say that the same questions which I have alluded to as being still in dispute as regards the cultivation of tea, present themselves when dealing with coffee-growing.

The important matters of elevation, aspect, and shade, are by no means determined, nor are they attended to as they ought to be. The nature and requirements of the soil have not been sufficiently studied, whilst there is much to learn in regard to manures, their use and relative values. Lastly, there are diseases and injuries to which the coffee plant is liable, but which have not yet been successfully combated.

Elevation.

A suitable elevation, as in the case of tea, would seem to have much to do with the successful cultivation, though along with it must be taken the consideration of rainfall. The Bartchinhulla estate is about 3,000 feet above sea-level, and the rainfall is from 90 to 100 inches, but at Messrs. Cannon's estate, where coffee of the highest repute is grown, the elevation is 4,500 feet and the rainfall is only 60 inches.

Soil.

The kind of soil, or rather, its earlier history, is a point of the highest importance. If the land has previously been old forest land, thinned for the purpose of growing coffee, it is likely to do well, but if it be that which has before been under cultivation, more especially of the class known as *kumri* cultivation (in which the land is cleared by cutting down the wood, setting fire to the vegetation, and growing crops without manure of any kind) it is not nearly so valuable.

Shade.

The aspect must be studied, chiefly in the matter of shade, while both the presence of shade and the kind of shade provided are most essential points. Perhaps nothing affecting the cultivation of coffee impressed me more than the importance of shade. I have been over estates where shade has been attended to, and I have noticed the healthy and natural growth of the bushes. I have also been to other estates where shade has been neglected and dependence has been placed upon heavy manuring. The result has been that a *forced* unnatural growth of the bushes has taken place and an unhealthy appearance has been caused by the presence of a heavy crop with but very little leaf or young wood. A heavy crop of berries may in this way be produced for a few years, but then the bushes will in all probability fail, and in the end will not succeed like the shade-protected and less forced bushes, even though, for the time, the latter may yield a lesser crop. A sure sign of the land being too highly manured is the appearance of shoots all up the stem. The indication of a good bush is, on the contrary, the healthy growth of new wood on the branches to form the fruit-bearing branches of the year to come. I have little doubt that the failure of many coffee estates is due to the clearing away of the trees, and the neglect to provide other shade. The provision of proper shade constitutes a study in itself, to which too much importance cannot be paid, and if it be neglected it cannot be made up, more than temporarily at least, by any quantity of manuring or other means. The amount of shade should vary with the aspect and be so arranged as chiefly to protect the plant from the sun at every point during the hours when it is at its fiercest. It is recognised that trees differ very much in their suitability as shade-givers. While some supply but little leaf deposit for renewing the soil and spread out their roots along the surface of the ground, thereby depriving it of moisture and nourishment, others such as the *Jack-fruit* tree, and the *cubbusarree, goni, mittli, poonarul,* &c., are of a different habit of growth, and afford a large leaf deposit. Nor is it enough simply to provide shade at the outset, but there should be a *succession* of shade, the older and taller trees being successively removed for timber or fuel as the younger ones come on to take their place.

Tillage.

"Renovation pits."

The mechanical cultivation of the soil must be closely attended to, for it must be kept constantly stirred and not be allowed to get hard. To go on the land when it is wet is certain to do great harm. Perfect drainage is of the highest importance. Holes called "renovation pits" are dug on sloping ground in order to hold up the soil and prevent it from being washed away by the heavy rains in the wet season. These are generally 3 × 2 × 1½ feet, and are put between every four bushes; into them the leaves which fall from the shade-trees are swept, and in them the fine earth is retained as it washes down the slope. When the holes are again dug, this earth and leaf mould is spread around the stems of the shrubs. But I could not help thinking that the "renovation pits" were often unnecessarily numerous and close together. The digging of them is laborious work, and the ground is apt to get somewhat consolidated, besides which, in the digging, many of the rootlets of the coffee-plants are cut across and sometimes even the larger roots too. Therefore I think that the number of "pits" should not be greater than is necessary in order to stop the surface wash. At present it is the practice to regard these pits as means of bringing the subsoil to the surface, as well as of catching any wash, or of holding vegetable matter. It by no means follows that it is always an advantage to bring the sub-soil up, for it may be poorer in quality and the richer top-soil may thus be buried.

Soil-constituents.

As to the soil itself, judging from analyses which I have made of coffee-soils from Mysore, there appears to be clear evidence (*see* paragraph 63, as also Appendix B.) of the want of lime in the laterite soils, also that phosphoric acid and potash (*see* paragraph 65 and Appendix B.) are less abundant than in soils of alluvial nature in other parts of India. The frequent use of bones by coffee planters as a manurial agent is a support to the belief in the need of phosphatic manures, and it is probable that potash-containing manures might also be usefully employed. In Appendix B. I give some detailed analyses of Munjerabad coffee soils, and I would, in passing, comment on their richness in vegetable matter and in nitrogen resulting therefrom. This is accounted for by the fact that the land is old forest land, and it is likely that lime and mineral ingredients are what the soils require rather than more vegetable matter such as would be contained in oil cake, cattle-dung, &c. It is, indeed, quite possible that over-richness in nitrogen may produce a rankness of growth, and over-development of leaf to the exclusion of berry. In other cases, and where a lesser richness of surface soil is found, the reverse may be the case, and there may be decided need of organic manures. All soils cannot be treated alike, but each must be considered in its own special relations.

Application of manures.

Differences of practice occur in the manner of applying manures, some planters preferring to throw manure broadcast and to fork it in, others thinking it better to dig a trench round the bush about 1 foot or 1½ feet from the stem, and to put back the soil mixed with whatever manure it is intended to apply. But I am not aware of any comparative experiments that have been made in order to test which is the better plan, and, indeed, it would very probably be found best to put one kind of manure on in one way, and another in a different way. The plant food thus supplied should be put where the rootlets can best avail themselves of it, and therefore I should be in favour of scattering manure about rather than of accumulating it in one spot or even in a circle, so long as it is not too widely scattered or put beyond the plant's reach. Bulky manures, such as cattle-manure, leaves, and similar vegetable matter, require to be incorporated with the soil, so as to exercise a beneficial mechanical as well as chemical effect on it, whereas soluble salts, such as potash manures, may well be sown on the surface or be lightly forked in. The time of application will also differ according to the nature of the manure, bones and other materials which take long to decompose being better suited for early application, and more readily decomposable or soluble manures for a later dressing.

If coffee planters would make a few small but careful experiments for themselves they would certainly be able to obtain more information as to their particular land than could be given by anyone advising them, but who does not possess the requisite information as to the soil, the situation, and other local conditions, or even as to the manures which are readily obtainable. Manures, such as bones, oil cake, &c., are too generally used because they have always been used, and because there is a general belief in their utility, but it is more than probable that in some cases large sums are needlessly expended on them, while, in others, lack of lime, potash, or other soil-constituent, may be responsible for a diminishing yield.

Diseases and injuries of the coffee plant.

364. The coffee-plant, like the tea-shrub, has its own particular enemies, of which the chief are the "borer" and the "leaf disease." By planting good kinds of shade trees the "borer" has been largely suppressed, and is now but little dreaded under the best conditions as to shade. In open plantations or under bad kinds of shade trees "leaf disease" inflicts much damage, but not under good shade or on well-cultivated land. As to liability to disease, the most that can be said is that if the plant be maintained in good active growth, and not be unnaturally forced, it is less prone to disease and attacks than if the soil be not maintained in fertility, or if the plant be forced on so as to produce berries to the exclusion of a fair proportion of leaf.

Mr. John Hughes has examined healthy and diseased leaves of the coffee plant, but the analyses, though showing the comparative poverty of the diseased leaves in soluble organic and mineral constituents, do not point to the presence or absence of any particular constituent which might be considered deficient in the soil or be supplied in manurial form. Sulphuring and limewashing have been put forward as remedies for "leaf disease," and I might suggest another viz., the use of "blue-stone" (sulphate of copper), in the form of the mixture with freshly slaked lime, known as "Bouillie Bordelaise," and already used with much success in vine cultivation. Unfortunately, the difficulty of transport, and the difficulty of getting labour, would militate against the success of such remedies, and against their extensive application even if they should be found to be protective in character. But it would be well worth making experimental trials in order to ascertain the efficacy of any such applications.

Two main difficulties in coffee-growing.

365. Two main difficulties which coffee planters have to contend with are, that they cannot get enough labour and that they cannot get enough manure. As to labour, although high wages are given (Rs. 7 per month for men, and Rs. 5 for women), it is very difficult to procure enough just at the time when it is most wanted, while, as to manure, the difficulty and cost of transport are heavy, and there is not a sufficient supply of manure to meet the demand. The extension of railways will undoubtedly help much in removing the difficulties both as to the supply of labour and that of manure.

Cardamoms.

Cardamoms.

366. Associated with coffee-growing, more especially in Coorg, is the cultivation of Cardamoms, an industry which, until lately, was most remunerative, and to which I would merely allude in passing. It is found that after continuously growing this crop for some time, the produce declines materially, and it is clear that consideration ought to be turned to the manurial point of view of the cultivation, a subject which up to now has been quite neglected.

Tobacco.

Tobacco.

367. The cultivation of tobacco is one on which great care is bestowed. Like opium and sugar-cane, the crop carries with it considerable profits, but it is almost entirely grown upon good land and where both manure and water are available. Speaking generally, the crop is grown in rotation with other crops, but it is not unusual in some parts to grow tobacco year after year on the same land. In Gujarát (Bombay) and Sind it is the common opinion that the quality of tobacco is much improved by the continuous growth of it for many years on the same spot, and fields can be pointed out which have produced tobacco for 40 years and more, and are specially noted, the produce often fetching quite "fancy" prices. Manure is, of course, used lavishly. But this continuous growth of tobacco in certain districts is remarkable, and well deserves investigation, inasmuch as in other parts, for example, Khándesh and Belgaum (where the produce is also good), the cultivators will not take a tobacco crop oftener than once in ten years, alleging as the reason the impossibility otherwise of keeping down the parasite (*Orobanche Nicotiana*), which affects the plant so seriously (*see* later on, paragraph 372). Tobacco is grown principally as a "garden" (irrigated by wells) crop, but sometimes also as a "dry" (unirrigated) crop, the seed-bed only being watered by hand. I have instanced the preference of the grower of tobacco for particular kinds of water, and in paragraph 99 I have given an analysis of a well water which had the reputation of being specially suited to the crop. I also mentioned in paragraph 133 that in some parts it is the custom to spread round the plants earth which is impregnated with nitre.

The cultivation very careful.

So far as the cultivation goes, I see nothing in which the *raiyat* can improve, for, like other "garden" crops, tobacco is one over which no trouble is spared. It may be possible to get better information as to the effect produced by manures of various kinds, such as cattle-manure, nitre, oil-cake refuse, &c., upon the quantity and quality of the leaf, but this will hardly be the case so long as the Native uses his present crude methods of curing. When, however, as is now beginning to be done in Madras, private firms turn their attention to the proper manufacture of tobacco and cigars, there will be the call for guiding the cultivation also in the most favourable direction.

Manuring for tobacco.

Experiments at Nadiad.

368. In Gujarát (Bombay) a great deal of tobacco is grown. At Nadiad I met Rai Bahadur Becherdas Viharidas Desai, a most enlightened and leading agriculturist, who has given a great deal of attention and also money in attempts to improve the growing and the curing of tobacco. At the farm of the Nadiad Agricultural Association, of which Mr. Becherdas

Desai is an active supporter, many experiments have been carried out, and are still in progress, in order to find the manure best suited to the tobacco crop. Thus, the effect of the following manures was being tried at the time of my visit: cow-dung, goats'-droppings, castor cake, saltpetre, and tannery refuse. The general conclusions obtained thus far are, that saltpetre gives the largest yield, but does not produce a tobacco which is relished, and that for quantity and quality together, the best results are given by the goats'-droppings and by the tannery refuse. Mr. Becherdas Desai, in addition, has cultivated tobacco on a large farm near Nadiad, and has endeavoured to introduce the produce into the European market. Though the tobacco is pronounced by experts as being carefully cured, a peculiar strong flavour is noticeable in the smoking, which renders the leaf unsaleable. Mr. Becherdas Desai is quite cognisant of this, and has tried long, though without success, to ascertain whether the drawback lies in the growing or in the curing. Finally, he has had to give up the attempt to create a European sale for the tobacco.

Native method of curing tobacco.

369. Curing of tobacco as conducted by the Native is done in a very primitive way.* The leaves are not removed one by one when ready for picking, but, after a few spots have begun to appear on the lower leaves, the entire plant is cut off close to the ground, and is left exposed to the night dew. Next day the plants are arranged in small circular heaps, about two feet high, with the stalks outwards. At the close of the day the heaps are opened, and the leaves are spread out for the night. The next day they are heaped again, and so on until after about five days they begin to turn yellow. Then the plants are hung upon horizontal poles for 15 to 20 days, the stalks being pressed close to each other. After this the leaves are again packed in square heaps, and these heaps are opened and re-packed every two or three days. The leaves begin then to sweat and finally to turn black. This blackening is a sign of fermentation being finished, and the leaves are then stripped off the stalk and tied up in bundles and baled. Often, crude molasses (*jagri*) and water are sprinkled on the leaves after fermentation is over.

Improvement in curing.

370. This process of curing is evidently a very crude one, and admits of very great improvement. The curing of tobacco requires every stage to be carefully watched, the temperature to be observed, and fermentation to be induced or checked at the exact point which experience has determined as being best. Every leaf indeed should be treated as a unit by itself, and not simply as one of many leaves comprising a bundle or heap. But it cannot be expected that the Native cultivator will ever be able to do much more in this direction than he has done, and, wherever a better leaf is required, it will have to be obtained through the establishment of separate curing-places such as those which have been started in the Madras Presidency, and which will be under the care of practised "experts."

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* This description is taken from a Report by Mr. H. Caine, of Madras (Bulletin No. 4, 1889–90, Agricultural Department, Madras).

Prospects of the industry.

371. Endeavours have been made by Messrs. Begg, Dunlop, & Co. at Pusa in Tirhoot, and also at Ghazipur, North-West Provinces, to establish tobacco-growing and manufacture for the European market. Considerable advance has been made upon native methods, but it cannot be said that the undertaking has in either case been successful. A fine or even fair quality of leaf has not as yet been produced, though whether the soil, the climate, or the curing, has been at fault has not been ascertained. The failure to grow a high-class leaf in the above places and also in Gujarát may be due partly to the soil, but more probably to the climate, which is not sufficiently uniform throughout the year, but exhibits extremes of dryness and of wet at different periods. For this reason the more regular warmth met with in Southern Madras and the greater freedom from extreme conditions may account for the larger measure of success which has attended the efforts in that Presidency to establish the manufacture on an improved basis and with the assistance of expert knowledge from other countries. The prospects of the industry in Southern India are decidedly encouraging.

Tobacco parasite.

372. The tobacco plant has a great enemy in the *Orobanche Nicotiana* or "*Bodu*," a vegetable parasite which grows out from the root-stock of the plant. It is an annual, but the seed is readily propagated and is hard to get rid of. It is very certain that it attacks weakly plants by preference, and that it occurs on poor rather than on rich soil. The only way to effectually remove it is to detach it from the tobacco plant before the seeding of the parasite has begun. Being an annual its preparation may thus be prevented. Thorough hoeing of the land is very necessary, and careful cultivation is said to keep it down (*see* paragraph 367).

Flax and Jute.

Flax.

373. Flax or linseed is grown in India entirely for the sake of the seed, and not for the fibre. Indeed, experiments which have been made would seem to point to the ordinary linseed of the country being best adapted as an oil-giving and not as a fibre-yielding plant. It has been urged that considerable improvement in the preparation of fibre both from the linseed plant and from *san* hemp (*Crotalaria juncea,* which is not really a hemp at all) could be effected if men skilled in the manufacture could be obtained from other countries to teach the Native how to dress the fibre. But more than this is involved. It would, firstly, have to be ascertained what kind of seed is the one best calculated to produce a good fibre rather than seed; and, secondly, the method of cultivation would have to be altered. In order to produce fibre, the plant must be sown thickly so as to grow tall and upright and not short and bushy, as is the case at present. Further, it is more than likely that a good fibre-producing plant could only be grown well on a particular class of soil, a sandy and not a clayey one being requisite. The experiment has been tried in the Punjab, but the manufacture of flax was not found to be a profitable one. Mr. Ozanne also tried the growing of flax for fibre at the Bhadgaon (Bombay) Farm, but it did not succeed, for, even though thickly sown, the shrub was found to branch too much, and would not grow properly. When tried as a rainy-season crop, Mr. Ozanne found that it would not stand much wet, owing to its liability to a kind of "rust," and when tried as a cold-weather crop it proved to be exceedingly delicate. Again, the preparation of flax fibre is much harder than that of either the *san* hemp or of jute, and it needs skilled supervision and the employment of an "expert" in flax-dressing. But the principal objection is that it is impossible to grow seed and fibre on the same plant; if seed be desired, the fibre must be sacrificed, and *vice versâ*. As long, therefore, as the cultivator gets a good profit by selling the seed he is not likely to risk the production of fibre, and if he is wanted to grow flax it must be made worth his while to do so.

Even as regards *san* hemp, (the preparation of which for fibre is easier than that of flax), its place as a fibre has been virtually taken by jute.

Jute.

374. At Serajgunge in Eastern Bengal I had the opportunity of seeing the cultivation of jute, and also its preparation and manufacture. The damp hot climate that prevails here especially favours the crop, and, inasmuch as it is mostly cultivated on rich inundated land which is constantly silt-renewed, there is little need of manuring, as a rule. Occasionally cow-dung is used, or a pulse-crop is fed off previously to sowing the jute.

Silk.

Silk.

375. The decline of the Bengal silk industry is believed to be in great measure due to the spread of certain diseases among silkworms. The worst of these is known as *pebrine*, and so serious have been its ravages that an effort was made a few years back to investigate its nature and the means of prevention. Mr. N. G. Mookerjee, of the Bengal Agricultural Department, was deputed to Europe in 1888 to study the methods of silkworm-rearing practised in Italy and France, and more especially to acquaint himself with the system introduced by M. Pasteur, of examining microscopically the moths intended for laying the eggs or "seed," as they are termed. The eggs of any moths which are found to be affected with disease are rejected, and only healthy "seed" is kept. It was hoped in this way to establish a pure race of silkworm free from disease, and by distributing the pure "seed" to silkworm-rearers to thus get rid of the evil. A central "seed-station" was subsequently started at Berhampore.

It must be acknowledged, however, that the work has not been altogether satisfactory, and the steps taken in India have not been successful in perpetuating silkworms which are free from disease, at least in the silk districts of Bengal. Mr. Mookerjee, who has had charge of the experiments, has been able to rear silkworms free from disease in places such as Dehra Dun which are far removed from the silk districts, but as soon as the seed is removed to the silk districts of Bengal *pebrine* appears and it is no longer possible to keep pure "seed."

Grain-cleaning.

Grain-cleaning.

376. The export of wheat and oil-seeds from India has introduced important considerations as to the cleaning of grain and seeds, and on these I wish to touch.

"Dirty" condition of Indian wheat.

Indian wheat has, without doubt, acquired a name for being "dirty," and of being inferior to the Canadian and American wheats put upon the English market. It is stated that a considerable amount of earth, and of seeds other than wheat, come with the grain, and that this necessitates special cleaning of the deliveries after their arrival in England. In addition, Indian wheat has to be washed, partly in order to soften it (Indian wheat being very hard), and partly so as to get rid of the earth and dirt which are invariably found along with it. A lower price consequently rules for Indian wheat, and many millers who would be willing to purchase it are kept back from doing so by reason of the expense involved in providing special appliances for cleaning the grain.

The basis of sale of wheat.

377. It has been customary to sell Indian wheat on the basis of its containing a certain amount of impurities, the exact amount varying with the place of export and the time of year when export takes place. In the case of Calcutta wheat, 5 per cent. of impurities used to be allowed for ante-monsoon shipments (previous to 1st July), and 6 to 7 per cent. for post-monsoon shipments (after 1st July). For Bombay wheat a somewhat lower percentage, viz., 4 to 5 per cent. was allowed, but wheat from Karachi was reckoned as being more impure than that from Calcutta or Bombay, and the ante-monsoon season also extended to 30th September.

The causes of wheat being shipped in this impure condition were alleged to be the inferior cultivation of the Indian *raiyat*, the habit he has of growing wheat, not alone, but as a "mixed" crop, and the imperfect means at his disposal for threshing out and cleaning the grain. It was argued that as the cultivator threshes his corn by treading it out upon an earthen floor with his bullocks, the earth must of necessity get mixed with it; besides this, that the means of sifting out foreign seeds being crude, and the *raiyat* having no machinery for the purpose, impurities arising from the crops grown along with the wheat must prevent a good clean sample from being obtained.

How Indian wheat comes to be "dirty."

378. That a certain amount of foreign seeds and dirt finds its way into Indian wheat from the above causes is undeniable; but, as I shall presently show, this does not account for anything like the percentages of "dirt" which it has been the custom to fix. When first the export of wheat began to assume any considerable dimensions the purchase of shipments was conducted on the system of "mutual allowances," the buyers paying for any superiority in cleanness shown above the arranged limits, and the shippers paying for any deficiency. Samples of the different cargoes were submitted, on arrival in England, to the Corn Trade Association for analysis, and the percentages of impurity were fixed thereby. But it was soon found out that, despite the statements that had been made as to the *raiyat's* imperfect methods, Indian wheat generally arrived in so clean a condition that the buyers had in most cases to pay for the extra cleanness. They soon got tired of doing this, and accordingly dropped the system of "mutual allowances." They resolved only to purchase upon the basis of "fair average quality" (f. a. q.), this implying that the wheat might contain the percentage of impurity or "refraction," as it is termed, allowed according to the port and time of shipment, but they refused to pay for any superiority over the "refraction" limit, though they still claimed an allowance for any inferiority shown, leaving the exact amount to be settled by arbitration.

Intentional adulteration.

The result of this action soon made itself apparent. Indian wheat, which up till then had been coming over clean, now began to deteriorate, and the London or Liverpool buyer talked loudly of its "dirty" condition, and assigned this as a reason for giving a lower price for it than he would for Canadian, American, and other wheats. But the change in the character of Indian wheat was the direct consequence of the English buyer's action, inasmuch as the Indian shippers, finding that they no longer got a penny more for wheat which they sent over clean than for that which had the full allowance of impurity, naturally took good care not to ship any which had not the full amount of impurity. This has led to a deliberate system of adulteration of wheat being practised, and, however pure the grain may be when it comes off the cultivator's field, it is always *made up to* "fair average quality" as understood in the English market, before it leaves the place of export.

Attempts to secure purity of Indian wheat.

379. When this change in the condition of exported grain was brought about, strong representations were made by those interested in the Indian trade, and also by millers in England who had been using Indian wheat and would have gladly continued to use it had there not been the difficulty of dealing with it in consequence of the dirt and impurities it contained, and the expense they were put to in removing these. Messrs. McDougall Brothers, of Mark Lane, London, specially interested themselves in this matter, and laid before Viscount Cross, the then Secretary of State for India, much valuable information upon the subject. Messrs. McDougall's enquiries elicited the facts that not only was clean Indian wheat desired, but that an extra price would be paid for it, and increased use be found for it. The desire of the millers was that admixture should be limited by contract to 2 per cent.

Conference at the India Office.

Reports and papers were laid before Parliament in 1888 and 1889, and on May 8, 1889 Viscount Cross presided at a Conference held at the India Office to consider the question of Indian Wheat Impurities. In the course of his opening address his Lordship pointed out that no less than three million cwts. of dirt are imported every year with Indian wheat, and that this implies a useless and foolish expense.

The London Corn Trade Association on their part maintained that the condition of Indian wheat was a natural one, due to the methods of the *raiyat* in cultivating and threshing, and that the basis of 4 per cent. of impurity for Bombay and 5 per cent. for Calcutta wheat was accepted by shippers as being the normal condition of wheat as grown. Shipment on a 2 per cent. basis, they maintained, would imply cleaning at the place of export, and would necessitate English millers paying a proportionately higher price, which they would not be found willing to do. The London Corn Trade Association raised objections to selling wheat on analysis (in the same way that linseed is sold), and they deprecated Government interference in a trade matter which would gradually right itself and effect the desired improvement in time.

Views of Liverpool Corn Trade Association.

The Liverpool Corn Trade Association differed entirely from the London Association, and saw no difficulty in fixing a 2 per cent "refraction" standard, at least for Bombay wheat; they believed that if a 2 per cent. limit were fixed in England the wheat would soon come from India of the required purity. The term "fair average quality," they felt, was a very elastic one.

Views of millers.

A point of considerable importance was raised by millers in the Midlands and other inland counties of England. They pointed out the disadvantage they were at in having to pay not only for the extra dirt, &c., coming from India to London, Liverpool, or other English ports, but that they had to pay as well for its conveyance at high rates along English railways. In this way the smaller millers and those inland were much prejudiced, for they could less afford than the larger millers to put up the requisite machinery for removing the impurities which had been deliberately put in and for which they had had to pay extra carriage.

It was not to be expected that any general agreement could be come to at the Conference, when interests so divergent were concerned, but, although a few large millers, who had already gone to the expense of setting up special machinery for dealing with Indian wheat, were in favour of matters remaining as they were, the National Association of British and Irish Millers, and millers generally, strongly urged that improvement ought to be effected, that wheat should be shipped cleaner, and that wilful adulteration should be punished.

380. In India itself, enquiries were made, and efforts were put forward to induce a trade in clean wheat. The Reports of the Bengal Agricultural Department showed that the unsatisfactory state in which wheat was exported was not due to the inferior cultivation and dressing which it received from the *raiyat,* but that when clean wheat was offered, the merchants, owing to the action of the buyers in England, positively declined to give any better price for it than for wheat with 5 per cent. of impurities. Mr. Finucane, Director of the Bengal Agricultural Department, instances that in August 1887 the Manager of the Dumraon Raj wanted to grow wheat largely and to supply it in a clean state, if he could get a remunerative market for it. He proposed giving the *raiyats* advances of seed and money by way of inducing them to grow wheat alone and not as a "mixed crop;" also to set up machinery for cleaning wheat. But he was obliged to give up the idea, for the merchants would not give a higher price, and, what was worse, the clean grain was deliberately mixed with mud so as to make it up to the 5 per cent. "refraction" before it left for shipment to England. The manager of the Raj relates that, near Buxar, he used to sell wheat to an agent of a leading wheat-exporting firm, and that his servants were instructed how to make little pellets out of mud and water, which would resemble wheat, and to mix 2 maunds of this earth with every 100 maunds of grain whenever the wheat was found not to contain 5 per cent. of impurities.

Attempts made in India to supply clean wheat.

Bengal Agricultural Department.

381. The Bombay Chamber of Commerce have repeatedly urged the London and Liverpool Corn Trade Associations to accept a basis of 2 per cent. of "impurities," and have said that, were it adopted, there would be no difficulty whatever in getting *any quantity* of wheat cleaned to that extent. To these proposals the Liverpool Association seemed to be favourable, but the London Association declined to assent. In place of it they proposed, in November 1889, the following "refraction" limits for ante-monsoon shipments: 3 per cent. for Bombay wheat, 4 per cent. for Calcutta wheat, and 5 per cent. for Karachi wheat. Of these "total impurities" about 1½ per cent. was to be "dirt."* Somewhat higher percentages were fixed for post-monsoon shipments. The Liverpool Association joined in the recommendations. In vain the Bombay Chamber pointed out in reply that the analyses of Bombay wheat, as given by the Official Analyst of the London Corn Trade Association, showed even less impurities than the latter Association proposed, but so the matter stands.

Proposals of Bombay Chamber of Commerce.

Replies of London and Liverpool Corn Trade Associations.

382. I was naturally desirous of forming my independent conclusions upon the question of clean wheat, and therefore made my own enquiries. Mr. John Marshall, of the Bombay

My own enquiries.

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* The term "dirt" includes earth, chaff, and miscellaneous weed seeds of no intrinsic value.

Chamber of Commerce, Mr. Wishart (Cawnpore), Mr. H. M. Ross (Calcutta), and others, kindly gave me much information as to the practices of the trade; but, in addition, when pursuing my general enquiry up-country, I kept this object, among others, in view. I ascertained that each country, such as England, France, Italy, &c., to which Indian wheat is exported, has its own requirements, and wants particular grades of purity accordingly. Wheat comes into Bombay, for instance, of all degrees of impurity, containing, it may be, 2, 4, 6, 8, or even more per cent. of "impurities," and, before being shipped to its destination, it is *made up* to the particular degree of impurity required by each country to which it is being sent. It would be quite easy, I am assured, to clean all wheat to 2 per cent. of impurity. If the English merchants really want to have clean wheat they have only to insist upon its being supplied, and it would at once be forthcoming.

Adulteration of wheat seen by me.

Any doubts that I may have had as to wilful adulteration of wheat being practised were set at rest by my seeing, as I was passing Changa Manga railway station (in the Punjab), a large heap of wheat being deliberately mixed with earth. This was going on in full view of everyone.

The quality of wheat from the cultivators' threshing-floors.

383. My attention was next directed to ascertaining how the impurities that are found in wheat exported to England find their way into the grain. For this purpose I endeavoured to find out what the quality of wheat is as it leaves the threshing-floor of the *raiyat*, whether, in fact, it *does* contain all the dirt that it has been represented to have, for instance, the mud from the threshing-floor, and the gram and other seeds from the "mixed" crops grown with the wheat.

Accordingly, when staying at Cawnpore with Mr. Holderness, Director of the Agricultural Department of the North-West Provinces and Oudh, I obtained through his Personal Assistant, Mr. Lachman Parshád, six samples of wheat which were taken, according to my detailed instructions, direct from the threshing-floors of cultivators in the neighbourhood of Cawnpore, and just as the wheat was about to be sent to the nearest *bazár* for sale. The wheat was accordingly in the state that it left the cultivator and as it passed into the hands of the local traders for transmission to agents of the large wheat-exporting firms, and for subsequent despatch to the port of shipment.

The heaps of wheat as they lay on the threshing-floor, ready for removal and sale, were carefully sampled by turning each over and drawing from it handfuls from different parts, turning it over again and taking fresh handfuls, and so on, until an average of the whole was obtained, which, by subsequent division and sub-division, was reduced to a lesser bulk. The final samples were sent to me and the separation of the wheat and the impurities was carried out in my presence; the results of the separation were as follows :—

TABLE XIII.

Mechanical Analyses of Samples of Wheat taken from Threshing-floors of Cultivators in the Cawnpore District.

Mechanical analysis of samples of wheat.

No.	VILLAGE.	IMPURITIES.				CLEAN WHEAT.
		(a.) Gram, and other Pulses, with Large Earth.	(b.) Barley, Chaff, Immature Wheat, &c.	(c.) Rape, Small Weed-seeds, and Fine Earth.	Total Impurities.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*
1	Binaitpur -	—	—	—	·15	99·85
2	Cawnpore -	·35	1·18	·24	1·77	98·23
3	Gotaya - -	·20	1·34	·24	1·78	98·22
4	Likhanpur -	·16	1·72	·28	2·16	97·84
5	Rawatpur -	—	·68	·03	·71	99·29
6	Nawabganj -	—	1·11	·12	1·23	98·77
		Average of six samples - - -			1·30	98·70

NOTE.– No 1. This sample was exceptionally clean, and the impurities were too small to classify.
„ 2. (*a*) mostly *Lathyrus sativa, mung*, and gram; (*b*) barley and small wheat; (*c*) rape.
„ 3. (*a*) *Lathyrus sativa, mung*; (*b*) small wheat; (*c*) fine earth.
„ 4. (*a*) *Lathyrus sativa*; (*b*) barley and small wheat; (*c*) fine earth.
„ 5. (*b*) oats, chaff; (*c*) rape.
„ 6. (*b*) small wheat, oats, barley, earth; (*c*) weed-seeds, fine earth.

Other details of the Analyses are given in Appendix N.

From my own inquiries, therefore, I am convinced that the wheat, as it leaves the *raiyat's* threshing-floor, contains only about 1¼ per cent. of anything but wheat, and that there would be no difficulty whatever in supplying clean wheat on a basis of 2 per cent. "refraction," if only it were wanted.

There is another significant feature, namely, that if the earth that is so much complained of came from the threshing-floor it would much more probably be the fine crushed earth and not the small lumps which are so generally found in imported wheat. The case of wheat is different to that of linseed, for, while the latter is generally *pulled up* by the roots along with their adhering earth, wheat is, as a rule, *cut* and not pulled.

The real way in which "dirt" gets into Indian wheat.

384. The charge against the *raiyat*, that he sends dirty wheat into the market is, accordingly, not substantiated. What really happens is, I believe, that the traders or middlemen between the cultivator and the exporter all have their profit to make out of the wheat as it passes down to the place of export. This they do, as I myself saw being done at Changa Manga station, by mixing earth or foreign seeds with the wheat. The middlemen take good care that the cultivators send them the wheat clean, otherwise they would not be able to make their own profit out of it, and if the *raiyat* delivered the wheat to them dirty they would refuse to take it. But, as the grain passes on from hand to hand, each man makes his little profit by mixing other material with it, and finally it reaches the place of export; here it is *made up* according to the requirements of the trade with each country, and thus in the case of wheat sent to England, the 5 or 6 per cent. of impurity necessitated primarily by the action of the London Corn Trade Association, is gradually added, shipped to England, and on its arrival has all to be taken out again.

That this is what really takes place was forced upon me still more strongly by an examination which I made of a sample of wheat taken from a bulk in Cawnpore market, exposed for sale there. This bulk I saw myself, and had a large sample of it drawn, and the impurities were sifted out and weighed in my presence. The results were :—

Analysis of wheat from Cawnpore market.

	Per cent.	
Clean wheat - - - - -	96·37	
Barley - - - - - -	·88	3·63
Gram, *dal*, and other pulses -	1·56	
Small barley and chaff - -	·44	
Rape, unripe wheat, earth, &c. -	·75	
	100·00	

This wheat was of the description known as "No. 2 Club."

A noticeable difference is found between the amount of impurities in the sample from Cawnpore market and that in the samples from the cultivators' threshing-floors in the surrounding district. This tends to support the view which I have expressed, that the impurities find their way in as the wheat passes from hand to hand.

I found also that at Cawnpore the refuse from the flour-mills in the town had a substantial value in the market.

The fault lies with the home buyer.

385. I lay the blame for the impurity of Indian wheat not upon the *raiyat*, nor yet upon the exporter, but upon the home buyer, as represented by the London Corn Trade Association in particular. The home buyer *does not want* to have pure wheat. If wheat were sold on the basis of absolute purity this would lead to more arbitration upon samples, and would minimise speculation. If a margin of 4 or 5 per cent. of impurity is given, the buyer will look at a sample and judge very fairly whether it has 3 per cent. of admixture or more than this, but if the basis of sale were "absolute purity," or else 1 per cent. of impurity, there would constantly be arbitration as to the exact amount, and the buyer, instead of, as now, getting a delivery sometimes better than usual, and being able to resell it at an advantage, would have the element of speculation removed and only be able to sell on the certified quality.

The inducements to keep up the present system.

The presence of admixture in Indian wheat keeps its price below that of Canadian and other wheats, and thereby offers the inducement of a lower price to buyers, and promotes speculation. So long as the term "fair average quality" is retained the meaning to be attached to it will be a very elastic one.

Undoubtedly, too, not only are the merchants opposed to any change in the existing practice, but there are also large millers to whose interest it is to keep Indian wheat "dirty." They have put up extensive and costly machinery purposely to enable them to deal with Indian wheat, and, being able to buy the latter at the lower quotation, they secure an advantage over their smaller rivals who cannot go to the same initial outlay.

The "elevator" system.

386. It has been suggested that if the "elevator" system, which is in vogue in America and in Russia, were to be introduced into India, the grain might be screened in bulk and be graded at the different depôts, so that it would sell according to its ascertained quality.

Inapplicable to India.

But there are difficulties which make the system inapplicable to India. Apart from the undesirability of subsidising, as has been suggested, any private firm for a term of years to carry this scheme out, and apart from the impossibility of Government taking in hand the whole wheat trade of the country, there are considerations as to the nature and methods of cultivation which place Indian wheat on a different footing to that of other countries. In the first place, Indian wheat will not *keep* for any length of time, but is liable to the attacks of weevil; it is thus much better suited for bagging than for keeping and selling in bulk. Secondly, the number of different kinds of wheat grown is so large, and the individual areas over which they are distributed are so small, that to grade these numerous small lots would be a difficult if not impracticable task. In America and in Russia, for instance, we should find one single variety grown over a wide extent of country, but in India the wheat is grown on small patches, one kind in one field, another in another, a hard wheat here, a softer wheat there. Altogether, some thirty different descriptions of wheat are sent from India to Europe.

The remedy to abolish fixed rates of "refraction."

387. The real remedy for the condition of Indian wheat will be found in the abolition of fixed rates of "refraction." As long as these are maintained the exporters will *work up* to them, but if the English buyers say that they must have clean wheat it will be speedily forthcoming. France and Italy have both refused to receive dirty wheat from India, and the consequence is that they have it sent to them clean. Russian barley is sold on a basis of 3 per cent. of impurity, and this plan works quite smothly. When clean linseed was insisted upon by Calcutta merchants the *raiyats* up-country soon began to screen it and to deliver it clean. At one time the same difficulties that exist with wheat occurred also with rice, but these have been now removed, and rice is sold on a "pure" basis.

The same might be readily done with wheat if the trade really wanted to have it clean.

Legislation may be necessary.

If, however, the trade are not willing to set the practice right themselves, there only remains the enforcement of legislation to oblige the sale of wheat on a "pure" basis, and to make it a penal offence to adulterate wheat, or to export or trade in adulterated wheat.

The trade, and in particular the London Corn Trade, have the power of remedying this themselves, but they have shown little disposition to do it, and it is, I think, time that stronger measures should be taken to oblige them to put the Indian wheat trade upon an honest basis.

Linseed.

Linseed.

388. My inquiries on the matter of grain-cleaning extended to linseed as well as to wheat.

A large number of samples were collected for me in the Central Provinces by Mr. T. C. Wilson, then Settlement Officer at Damoh, and by others of Mr. J. B. Fuller's (Commissioner of Settlements and Agriculture, Central Provinces) staff. Most of these samples were taken direct from the cultivators' stores or threshing-floors, and in the manner described before. The samples were brought by me to England, and the mechanical analyses were performed in my own laboratory. In Appendix O. I give the detailed results of analyses of 39 samples collected from different districts.

Mechanical analyses of samples from cultivators' stores and threshing-floors.

The seed was first passed through a coarse sieve which retained all coarse earth and large seeds, then through a finer sieve which retained the linseed, allowing the fine earth and small seeds to pass through. The amount of "sieved linseed" was thus obtained. Finally, the sieved linseed was hand-picked, and everything was removed that was not "pure linseed." The following table gives the summary of the results:—

TABLE XIV.

Mechanical Analyses of Samples of Linseed taken from Cultivators' Stores and Threshing-floors in the Central Provinces.

	Pure Linseed (hand-picked).	TOTAL Impurities.
	Per cent.	*Per cent.*
18 samples from Bilaspur district -	92·87	7·13
4 " " Raipur " -	93·94	6·06
2 " " Jubbulpore " -	95·81	4·19
2 " " Damoh " -	91·60	8·40
11 " " Nagpur " -	95·79	4·21
Average from all districts -	94	6

Further details of the analyses are given in Appendix O.

Linseed at Ralli Brothers' store.

To one sample in particular (No. 31 in Appendix O.) I would refer. This is one from the Nagpur district, and was taken at Messrs. Ralli Brothers' store, or "go-down," from linseed which had been brought in in carts for sale at the "godown."

It gave :—

	Per cent.	*Per cent.*
Coarse earth and large seeds	·63	
Fine earth and small seeds	1·18	
Stalks, chaff, &c., removed by hand-picking	·85	
	2·66	
Total impurities		2·66
Pure linseed		97·34
		100·00

The different samples give varying amounts of impurities, but, on comparing the results with those obtained in the case of wheat, it will be noticed that the average amount of impurity is higher when linseed is the crop. This is but to be expected, inasmuch as the linseed is generally gathered by pulling up the plant bodily with the roots and adhering soil, also the foreign seeds, short stalks, and chaff, are much harder to separate from linseed than they are from wheat. Yet it would appear from the results given above that when the merchants want well-cleaned seed, they can get it readily enough.

Method of purchase and export of linseed.

389. I ascertained at Bombay that the usual plan followed in buying linseed for export is as follows :—the seed is bought from the up-country *raiyats* by the dealers ; the latter bring it to Bombay or some other port and place it in the *bazár*. An intermediary called the *muccadam* buys the seed in the *bazár* and cleans it; he brings samples to the various seed-shipping firms, and covenants with them to supply a certain amount like the sample, of a definite percentage of purity and at a certain fixed price. The linseed is generally bought in India on a basis of 94 per cent. purity, and is sold to buyers in London and elsewhere on a basis of 96 per cent. The *muccadam* is responsible for the purity, and if, on arrival in England, the seed is found, according to the test of the Oilseed Association, to come out below guarantee, an allowance is made for it, and the *muccadam* has to pay this to the shipper. But if the English buyer gets a seed of higher purity, he is not called on to pay for anything above the guarantee. Accordingly, the shippers *chance* the deduction being made for anything below the guarantee, and take care not to send any seed of above 96 per cent purity. Formerly, linseed was bought on the "reciprocal basis," the purchaser paying more for the cleaner seed, and being allowed for that which was less clean. This clause, however, was eliminated by the home buyers, and at once the quality of linseed deteriorated, as it was no longer to the interest of the exporter in India to get pure seed.

About five years ago it was decided by the London Oilseed Association to buy upon the basis of "absolute purity," but this proved a dead letter, as there was no demand in the home market for "pure" linseed.

With linseed, as with wheat, it would be quite possible to get clean seed if there were the demand for it, but, unless buyers are willing to pay on a higher scale for pure seed, the trade will continue as at present and the seed be graded to just the percentage of impurity which meets the requirements of the market.

CONCLUSIONS.

CONCLUSIONS.

390. The improvement of particular agricultural industries, such as those connected with sugar, indigo, tea, coffee, tobacco, &c., would benefit agriculture generally. But the carrying on of these industries is, as a rule, confined of necessity to certain particular localities, and cannot be indefinitely extended over the country. Improvement in agriculture, through the modification of differences in practice, can have, therefore, but limited scope. It is rather to a bettering of practice in each industry that attention must be directed.

In sugar cultivation and manufacture, however, there are clear cases in which better methods are employed in some districts than in others, and it would be within the power of Agricultural Departments to extend the knowledge of the better practice. It is very certain that sugar cultivation might be very much extended, and that by better ways of dealing with the canes and with the expressed juice the outturn of sugar might be largely increased, and India become less dependent upon the importation of foreign sugar.

Beyond the work which Agricultural Departments can do in demonstrating the advantages of certain modes of cultivation and of approved implements such as the iron sugar-mill and the shallow evaporating-pan, there are numerous questions affecting the production of sugar which can only be solved by the application of chemical science. So much work is there to be done in determining the causes which influence the outturn of sugar, that it almost warrants the employment of a chemist for this industry alone.

The indigo industry is one which pre-eminently calls for the assistance of chemical knowledge, and for its application to the processes of the manufacture at every stage. In perhaps no other industry where chemical processes are involved is so little known of their nature or how they may be controlled. A skilled chemist should be set apart for this work alone. This is, however, a matter, not for Government, but for those engaged in the indigo trade.

The quality of Indian cotton is no doubt inferior to what it used to be, but the cause is the demand for cheapness, and the remedy is not with the *raiyat,* nor with the Government, but with the trade. It is advisable that seed of the better varieties of cotton should be preserved in case of a demand arising for them in the future; also, it would be very desirable to secure by recognised trade-marks the various kinds of cotton which are grown; Government can, however, do but little else.

In the cultivation and manufacture of tea, there are many points which call for the aid of the chemist. This has been already recognised by the Indian Tea Association. The same applies in some degree to the cultivation of coffee, and still more so to the curing of tobacco. The employment, however, of the necessary scientific assistance is a matter for those engaged in the particular industries rather than for Government.

The fact that the Indian wheat imported into England has the name of being "dirty," arises, not from bad cultivation or from carelessness on the part of the *raiyat,* but from the action of the English Corn Trade. Clean wheat is not desired by English buyers, and exporters consequently make up their cargoes to the requirements. Wilful adulteration of grain consequently takes place in India. If clean wheat were wanted it would be at once forthcoming. The elevator system is not applicable in the case of India. The remedy for "dirty" wheat will be found in the abolition of fixed rates of "refraction," but, unless the trade itself adopts the remedy, it will be necessary to make adulteration of wheat a penal offence, as also the export of, and trading in, adulterated wheat.

RECOMMENDATIONS.

RECOMMENDATIONS.

391. I recommend :—

The setting on foot of Enquiry by Agricultural Departments in order to ascertain the best methods of cultivation and manufacture of crops such as sugar-cane, indigo, tea, coffee, tobacco, &c., and the endeavour, by demonstrating these methods, to extend the cultivation and increase the out-turn.

The employment of chemical science in the investigation of problems affecting these industries, and more particularly that of an Agricultural Chemist in connection with the sugar industry.

The making it a penal offence to Adulterate wheat, or to export, or trade in adulterated wheat.

CHAPTER XV.

CHAPTER XV.

ECONOMICAL AND POLITICAL CONDITIONS.

ECONOMICAL AND POLITICAL CONDITIONS.

392. In my opening sketch (Chapter II.) of the grounds upon which I considered that improvement in agriculture was possible, I mentioned the existence of differences in agricultural practice which could not be traced either to physical conditions or to want of knowledge, but which resulted from varying economical and political conditions. As an instance, I mentioned the effect which pressure of population, or the absence of that pressure, would produce upon the agriculture of any part, and I indicated that a modification of the differences which exist might be accompanied by a change in the agricultural practice. Thus, if in one part the conditions of living are easy, the agriculture will often be found to be lax; whereas, when the struggle for existence is harder, the agricultural methods will frequently be more closely attended to. Another element which will affect agriculture is the extension of railways and other means of communication, resulting in the development of an export trade. Other influencing circumstances are the varying systems of land tenure, the relations of tenant to landlord and of people to the State, the indebtedness of cultivators, the want of capital in agriculture, and the subdivision of land.

Reasons for not treating of these in detail.

393. These and many others are matters which exercise an important bearing upon the way in which agriculture is pursued, and if I do not do more than touch upon them, it is not because I am not aware of their importance, but because I do not feel myself qualified to treat of them. They involve questions of economics, and an acquaintance with political conditions, the consideration of which belongs to a different sphere than that of the agricultural chemist. Besides this, I feel that a thorough knowledge of the people, the languages, and the political relations, are requisite before one can venture to speak to any good purpose upon these intricate points.

It may be said, perhaps, that if, whilst I acknowledge the importance of such considerations as the foregoing, I do not treat of them, of what use, then, are my suggestions? To this I reply that, even were the Government demand for land revenue remitted by one-half, it would not result in the production of that which Indian agriculture requires most of all, viz., more manure to put on the land. While this need remains unsupplied the actual produce of the soil cannot be increased, however low the rent payable by the cultivator may be. Nor can a better system of land tenure directly produce an increased yield of a single bushel per acre, nor can it provide wood to replace cow-dung, and so set free the latter for its right use upon the land. Improvement in tenure, remission of rent, &c., may make the condition of the cultivating classes better, but they will not provide more manure, better cattle, more pasture or better seed.

Small holdings and small capital.

394. The smallness of the holdings occupied by cultivators constitutes a limit to the possibility of improvement. The average size of a holding is probably below five acres, and each man's first concern is to provide food grains for himself and his family. Consequently it often happens that land which might grow highly remunerative crops is given up to the growing of grain crops, and the best use of it is accordingly not made.

Mr. Nicholson says of Coimbatore :—

> "The land is often handed over to poor tenants who cannot wait for rich "crops like sugar-cane and plantains, but must grow food grains. Sugar-"cane and plantains, worth 150 rupees per acre, would grow splendidly on "tens of thousands of acres of wet land, but, instead of this, 20 rupees are "spent to grow a crop worth 40 rupees."

The smallness of the area also limits the obtaining or the laying out of capital, as well as the benefits of superior implements, and the employment of better cattle. It has been rightly said that "what is wanted is not increase in the *number* of five-acre farms, but more *capital* put into the existing ones." It is not as if we were dealing with farmers occupying some two or three hundred acres each, and where capital, education, and enterprise are present; but it is the absence of these, and the subdivision of the land into small patches, that make the problem of improvement so hard a one.

Systems of land tenure.

395. The conditions under which land is held in the different Provinces of India have important bearings upon the agriculture. Under the *raiyatwari* system of Madras, for example, the State deals directly with the peasant proprietor, and the latter, so long as he pays the assessment which has been fixed, is able to do with his land as he likes. This, however, as Mr. Nicholson points out, begets a tendency to rent out the land to others, and to live upon the proceeds. Land may thus become the object of competition, and rich merchants frequently buy it as an investment, handing it over for cultivation by poor tenants who are themselves unable to put any capital whatever into it. There may, in this way, be undue extension of cultivation, the *raiyat* (here really a proprietor) being allowed to take up any quantity of land, regardless of whether he can do justice to it or not. A proprietor (*raiyat*), so long as he pays his fixed assessment, is able to rent his land to sub-tenants at any figure which he can obtain, and the sub-tenants become really tenants-at-will, liable to be turned out by a higher bidder. There is, consequently, a disinclination on the part of the sub-tenant to put money into the land, as, for example, by sinking a well;

whereas, to the proprietor there is the inducement to get the profits of a petty landlord rather than those of the hard-working cultivator.

On the other hand, a great deal of land is cultivated on the *metayer* or sharing system, the tenant paying for the cultivation and taking one-third or one-fourth of the produce and all the straw, and handing the remainder over to the landlord, the latter paying the Government assessment. The interests of tenant and proprietor thus become one.

Other systems prevail in other parts, each with its special advantages or disadvantages, but into these I must not enter, nor yet into the vexed matter of the influence of a permanent settlement as opposed to that of a re-settlement at intervals of 20 or 30 years.

Indebtedness of cultivating classes.

396. The natural indebtedness of the cultivating classes, and their recklessness in the matter of marriage expenditure and in litigation, are features which affect most seriously the possibility of improving the agriculture. But here, again, I am on ground where I can make no useful suggestion, and on subjects which have for long engaged, and now are more than ever occupying, the earnest attention of Government. By the introduction of the *taccavi* system of advances, and by loans for the purchase of seed, cattle, &c., in time of scarcity, the State has endeavoured to afford advantages to cultivators. But the latter have not as yet fully availed themselves of these advantages, the chief reason, in most cases, being that they are too deeply in the hands of the *baniya* or money-lender to offer any security for the advances made. The *baniya* is also the grain merchant, and it is he to whom the cultivator resorts for the seed which he needs before his crop can be sown. The *baniya* advances the seed, generally at exorbitant rates of interest, 25 per cent. for six months being quite an ordinary rate. But the cultivator *must* have the seed, and, having kept none over for himself, he resorts to the grain merchant, and thus a crop is often mortgaged even before it is grown. The sums spent by cultivators in marriages and displays are enormous when compared with their incomes, and for these, as well as for what they require in litigation, the *raiyats* repair to the money-lender. So long as there is anything on which security can be given, be it crops or be it land, the *baniya* is willing to advance, and when once in his hands it is seldom that the borrower comes out again. The accounts thus opened are rarely closed, and increase with astounding rapidity, interest being added to principal, and becoming the new principal. On interrogating cultivators in villages in the Central Provinces I frequently found that there was not one who was not in debt to some extent or other, and yet this was not because of the poverty of the soil or the inferiority of the crops. It was a habit, and one carried to such an extent that even those who were well able to purchase their seed went, nevertheless, to the *baniya*, if only to keep up friendly relations with him. In one case I found that an

Money-lenders.

Marriage expenses and litigation.

Indebtedness almost universal.

original debt of Rs. 120 had in a few years mounted to one of Rs. 600; a decree had been obtained against the borrower, but there was not the least intention of enforcing it, and it was elicited also that the same cultivator had already spent Rs. 400 in weddings, and was now about to spend another Rs. 50 in order to marry off his son.

Indebtedness hindrance to improvement.

Near Cawnpore I came to a village owned by four *zemindars*, holding 2,600 *bighas* (*bigha* = ⅝ *acre*) between them. All four were more or less in debt. One owed Rs. 5,000 and had mortgaged his land, paying 10 annas for Rs. 100 per month; a second had had several lawsuits, and had given the *baniya* a mortgage, the principal and interest to be repaid in ten years; a third had found an existing debt on the property when he came into it; and the fourth was Rs. 16,000 in debt. It was clearly impossible for these men to do anything to improve their tenants' position. The *zemindars* often are too encumbered to lay out money for well digging or for water supply by tanks. In parts of Chota Nagpur and the Central Provinces the forests have been cleared in consequence of the indebtedness of the landed proprietors, and in order to provide the latter with ready cash. In these ways the land passes from its hereditary possessors and falls into the hands of the money-lenders. In Thána (Bombay) almost all the land has become the property of non-cultivators. In the Hoshiarpur (Punjab) Settlement Report it is stated that:—

> " owing to the pressure of population and the special tendency to litigation, " and to spending large sums on marriages, the district is loaded with a " large burden of debt. The area mortgaged in the last 30 years has been " 116,000 acres, and that sold, 31,000 acres, or 16 per cent. and 4 per cent. " respectively of the cultivated area. Still the mass of the rural popula- " tion is better off than in most of the districts of the Punjab."

In the Central Provinces the amount of indebtedness is deplorable, and here it is the "absolute occupancy tenant" who suffers most, as he possesses the most rights, and they favour credit being given. The cultivators are, as a rule, comfortably off, and their being in debt is mostly the result of their ability to give security. To have a large sum in the *baniya's* book is, indeed, considered a sign of prosperity, and the possession of good credit. The existence of the *baniya* is the *result*, and not the *cause*, of the indebtedness of the *raiyat*, and amongst the surest signs of real poverty are the paucity of *baniyas* and the absence of jewelry on the females. The habit of getting into debt is strengthened by the almost total absence among the cultivators of any system of keeping accounts of income and expenditure.

Remedies for indebtedness.

397. The remedy for indebtedness is not the extermination of the *baniya*, even were that possible, but it will be found in an increased general prosperity, which will make the people more self-reliant and independent. Mr. R. H. Elliot, of Munjerabad, Mysore, told me that formerly the cultivators around his estate used constantly to come to him to borrow money, to pay the Government tax (he lending it to them without interest), so that they might not increase their indebtedness to the *baniya*; but that more recently, by having their own patches of land in coffee, and by working in plantations, the cultivators had, to a great extent, become free of the *baniya* and now rarely came even to him (Mr. Elliot) to borrow money.

Mutual benefit society at Hospet.

In a few cases the people have combined for mutual protection against the exorbitant charges of the money-lenders. In Hospet (Madras) a Mutual Benefit Society has been established in consequence of the money-lenders charging as much as 24 and 30 per cent. interest. The founding of the society has brought the charges of the *baniyas* down very considerably.

Messrs. Thomson and Mylne's action at Beheea.

At Beheea Messrs. Thomson and Mylne practically got rid of the native *baniya* by giving loans themselves to their tenants at a much reduced rate of interest. They pointed out to me, however, the absolute necessity that there was of being on the spot, and of knowing all the circumstances of the individuals who applied for loans.

Measures to curtail money-lenders' action.

In some instances it may be necessary to adopt stringent measures against the action of the money-lenders. It would certainly seem right, after what has been said, that enquiries should be made not only into existing debts but also into the history of these debts. Mr. J. B. Fuller told me that, according to an old Hindu law, no greater arrears of interest could be recovered at any time than amounted to the principal sum, and he thought that this rule might well be revived. Mr. Fuller was also in favour of Government granting loans to cultivators in some parts of the Central Provinces where good security was undoubtedly present, to enable them to pay off their debts to the *baniyas*. Their past experience of the extortion of the money-lenders had been so bitter that they would, Mr. Fuller thought, avoid its recurrence in the future if they could once be set free from it.

In the Saugor district of the Central Provinces the land belongs almost entirely to money-lenders, and, in consequence of the way in which the *raiyats* were ground down, the plan was devised of alleviating them by giving a lower assessment to the proprietors, provided that they undertook in turn to charge less to their tenants. This plan Government approved.

But the same remedy will not apply in one Province that does in another, and each will have to be dealt with according to its particular circumstances.

Want of enterprise.

398. Next to indebtedness and extravagance comes, as a drawback to agricultural progress, the *want of enterprise* sometimes met with among cultivators. Mr. Nicholson says of Coimbatore:—

> "There is a low level of social comfort, and the desire for progress is "prevented thereby; there is a disinclination to economy in time and "land, or to exertion in unusual times and seasons. The tendency is to "rent out the land, and to live on the proceeds."

Of Anantapur Mr. Nicholson writes :—

> "The total absence of effort and determined struggle, except on the "old lines, on the part of the people, is the cause of poverty."

Natural advantages and easy circumstances not conducive to agricultural improvement

This lack of enterprise is not always the result of the hardship of circumstances or the poverty of the soil. Frequently it may be the precise reverse. The Central Provinces have been described as a country of "rude plenty." The soil naturally produces enough to make the people comfortable, and for more than this they do not care. I have described in an earlier chapter (Chapter III., paragraph, 23) how improvement in circumstances might be produced were the cultivators in the wheat-growing districts to raise other crops than wheat. But they get all that they want, and their wheat gives them only about two months' or three months' work, at the most, whereas, if they grew other crops, they would have to work more, and also to irrigate the land. They are ready to admit that embanking of land (*bunding*) does good, but they will not go to the trouble and expense of doing it until positively obliged. As compared with the North-West Provinces, the density of population is 400 or 500 only to the square mile of cultivated land, as against 1,090, but the produce of wheat per acre is less than in the North-West. Were enterprise present, the wheat produce in the Central Provinces might be much more than it is. Assessment, too, is low as compared with the North-West; but a low rate of assessment is by no means synonymous with prosperous agriculture. Of many parts of the Central Provinces it might be said that, were the assessment higher, the agriculture would improve, in order to enable the increase to be met. Around Damoh the people have been obliged to embank their land so as to make the crops pay. It is certain that there are many parts where an increased difficulty of living would bring about improved practice of agriculture. It is not where population is least dense that the best agriculture is seen, but more frequently in the most congested districts, such as those around Benares, Azamgurh, and other parts of the North-West Provinces. As the struggle for existence becomes harder there is the inducement to put forth effort to meet its demands, whereas comparative ease in circumstances, a light assessment, and a naturally fertile soil, may prevent the exercise of energy, and may foster a backward condition of agriculture. Where such is the case an improvement can only be expected to come from the disturbance which time or pressure of population will make in the easy circumstances which exist.

Export of grain.

399. Attention has of late been turned greatly to the subject of the export trade in wheat, and it has been debated whether, in order to meet the distress caused by famine, the export of grain from India should not be restricted or stopped altogether. This question has been so fully and ably discussed by such authorities as Mr. J. E. O'Conor, Sir Edward Buck, and Mr. Holderness, that there is no call for me to say more than to emphasise the general conclusion come to that what is exported is practically the *overplus*, often specially grown for the purpose of export, and that if it did not pay the *raiyat* to export it he would soon give up growing it for this purpose. Besides, in time of scarcity, the price of wheat would rise in India along with that of other food grains, and it would then pay better to keep the wheat in the country than to export it. The amount of wheat exported is at present only about one per cent. of the total of the food grains produced, and only one-tenth of the total wheat crop.

Railways have, it is true, greatly facilitated export, but they have also done service in preventing fluctuation of prices in different parts, whilst their value, in time of famine, for conveying food to distressed districts can hardly be over-estimated.

CONCLUSIONS.

CONCLUSIONS.

400. In this chapter I have touched on some few of those economical and political conditions which have an important bearing upon agriculture and on the possibility of its improvement. Many others there are, such as social habits, emigration, &c., but my purpose has been merely to introduce a few, lest I should be thought guilty of ignoring their influence on the progress of agriculture. I have, however, expressed my inability to discuss them properly, and, besides, they are such as do not strictly fall within the scope of my more special enquiry.

I therefore refrain from making any recommendations under this chapter.

CHAPTER XVI.

CHAPTER XVI.

PRACTICAL AGRICULTURAL ENQUIRY.

PRACTICAL AGRICULTURAL ENQUIRY.

401. THE foregoing chapters consist of a review of the agricultural conditions of India, as they presented themselves to me during my tour. As each subject has been successively dealt with, I have indicated where improvement may, in my opinion, be effected.

In the concluding chapters of my Report it will be my object to discuss in detail the agency by which the suggested improvements may be carried out.

Scope of the present chapter.

I have had occasion, in almost every one of the sections, to point out the necessity which exists for a systematic enquiry into present agricultural practices, and to insist upon the acquirement of definite knowledge before attempts are made to *teach* any fresh system, or to carry out any extended work of experimental research.

It is with this matter of practical enquiry into agricultural conditions and methods that I shall occupy myself in the present chapter.

Necessity of combining practice and science.

402. Practical enquiry, or, as I may here put it, the obtaining of knowledge respecting agricultural practice, precedes both scientific enquiry and experiment. The scientist, without some knowledge of the practical issues involved, is unable to push his enquiries in the right direction, and, however able his researches, he may fail from being unpractical. Similarly, the experimenter, without a knowledge of what is done elsewhere, or of what is within the reach of the cultivator, may waste both time and money in trying what has no chance of ever becoming of any practical value.

The practical man must first become thoroughly conversant with what is being done in native agriculture, and with the conditions under which it is carried on; then the scientist may come in and explain the *rationale* of the practice, and may apply these principles to the extension of the better systems, and to the discovery of further resources; finally, by the happy combination of *science and practice*, the work of experiment may proceed in a definite and useful direction. In this way some advance in agriculture may be made.

The scope enquiry.

403. As I said in my opening chapters, I believe that it will be possible here and there to graft on to Native practice the results of Western experience, but the main advance will come from an enquiry into native agriculture, and from the extension of the better *indigenous* methods to parts where they are not known or employed.

In addition to the improvement of agricultural methods, there comes another most important branch wherein enquiry is absolutely necessary; this is the ascertaining of the requirements of different parts of the country in respect of facilities present in some, and deficient or absent in others. To this class belong those physical surroundings which I have summarised in paragraph 18 (Chapter II.), and which are comprised, mainly, in the supply of water, manure, wood, and grazing.

The necessity of enquiry recognised.

404. It must be clear to every one that, before any improvement in the agriculture of a country can be effected, the first preliminary is that a knowledge of the country, its conditions and its needs, be obtained. I may also say, without fear of contradiction, that, as regards India, comparatively little is known of its agricultural methods, and that they have only been, so far, the subject of casual and isolated enquiry by individuals. An organised system of enquiry, on the other hand, might result in the collation of definite knowledge of the agricultural resources and needs of the country.

By the Famine Commissioners.

The Famine Commission recognised the necessity of careful and organised enquiry in order to get a real knowledge of the agricultural state and conditions of India. I repeat the quotations from their Report, already given in paragraph 15 :—

> "The defect in the efforts made by Government to instruct the cultivator has consisted in the failure to recognise the fact that, in order to improve Indian agriculture, it is necessary to be thoroughly acquainted with it."

By the Government of India.

This view was also entertained by the Government of India in their Resolution of December 1881, in which they strongly urged the "prosecution of agricultural *enquiry*," and insisted that "it must precede any attempt at agricultural *improvement*." With this view the Government of India initiated the "agricultural analysis," which was to "indicate the condition of each tract of the country, alike for its protection against famine and for the improvement of the agricultural system."

Sir J. B. Lyall's opinion.

The Lieutenant Governor of the Punjab (Sir J. B. Lyall), in a recent note, says :—

> "I am altogether averse to attempts to give instruction in the practical business of agriculture . . . our positive and comparative knowledge of the subject are alike insufficient to warrant such an attempt at the present time."

Mr. J. B. Fuller's opinion.

In a Note prepared for the Agricultural Conference at Simla, in October 1890, Mr. J. B. Fuller writes :—

> "We have far more knowledge of European than Indian agriculture at our command . . . . laborious investigation is required before we can trace out the causes which have stimulated development in some parts of India, and have retarded it in others."

Opinion of the Madras Govenment.

The Note of the Madras Government presented to the same Conference says, in reference to the failure of experimental work in that Presidency:—

> "The experiments . . . were doomed to failure, either from want of "intrinsic suitability or from want of knowledge of indigenous practices "and conditions . . . the faults . . . would not have occurred had there "been a department of wide knowledge and full experience of native and, "especially, local practice and conditions."

The policy proposed by the Madras Government contains as its first recommendation, "the institution of a careful and "definite system of enquiry into existing practices;" and it mentions "the importance of enquiry as an essential prelimi-"nary to any original endeavours to improve Indian agri-"culture."

"Agricultural analysis" has been confined to the collection of statistics.

405. The "agricultural analysis" proposed by the Government of India has, up to the present time, been confined to the collection of Land Revenue statistics, and of information regarding the liability of districts to famine, and there has been no enquiry into agricultural methods with a view to agricultural improvement. The cause of this has been the absence of any organisation for the purpose, and the want of money for instituting it. Accordingly, whilst "Land Records" have been put on a satisfactory basis, agricultural knowledge and improvement have remained much where they were when the Famine Commission issued their recommendations.

This was not the intention of the Government of India.

That it was not the intention of the Government of India to confine an "agricultural analysis" to the collection of statistics is shown by the following extracts from their Resolution of December 1881:—

> "It is necessary to point out that the agricultural enquiry should not be "confined to the mere collection or collation of statistics, in the ordinary "acceptation of the term. An examination of the portion of the Famine "Commissioners' Report which deals with agricultural enquiry will show "that, in recommending with reiterated force an intelligent system of inves-"tigation, their final object is to urge through its means, and as a practical "outcome of its results, the policy of maintaining agricultural operations "at the highest attainable standard of efficiency. The Government of India "fully accepts this definition of a most important aim of agricultural "enquiry."

Again:—

> "From a system of agricultural enquiries . . . will follow the gradual "development of agricultural improvement in its manifold variety, and the "Government of India will be satisfied if, on the first constitution of an "Agricultural Department, the organisation of agricultural enquiry is placed "in the hands of qualified officials, to whom may be committed the subse-"quent preparation of carefully considered proposals for agricultural "improvement."

Sir Edward Buck, in reviewing, in March 1890, the position of the Department of Land Records and Agriculture, says:—

> "The agricultural conditions have only been studied with the view of "getting general knowledge as to the liability of famine, but not as

" regards agricultural practice, its advantages and the desirability of " extension, its deficiencies and possible renedies."

The field for enquiry.

406. The above extracts show abundantly that the need of acquiring knowledge of agricultural practice is fully recognised as a preliminary to any scheme of agricultural improvement.

Before considering what agency is best able to deal with the work of enquiry, it will be well to set out in more detail some special points on which that agency might usefully occupy itself, in addition to the general one of becoming acquainted with the systems of agriculture practised in different parts.

Firstly, it is important to ascertain the requirements of each district in regard to the provision of water, of manure, of wood, and of grazing, and to decide in what way the needs can best be met; whether, for instance, irrigation by canal or by wells is best suited; whether embanking of land should be done; whether "Fuel and Fodder Reserves" can be usefully formed; where grazing can be provided; whether the *taccavi* system of advances for agricultural improvement is properly brought before the people and utilised by them; and so on.

Secondly, it is desirable to ascertain where a transference of the practice of one part may be beneficially made to another part. Of this nature are, the embanking of land; green-manuring; hedging and enclosure of fields; sheep-folding; the use of leaves; the growing of fodder-crops; the ploughing of rice fields after harvest; the use of castor and other oil-seed refuse as manure; the utilisation of night-soil and town-sweepings; the planting of sugar-cane in furrows; the use of the iron sugar-mill and shallow evaporating-pan in sugar manufacture; the extended growing of sugar-cane, potatoes, and other crops.

Thirdly, there are a number of questions of a practical nature which await solution, and which, though mainly of the nature of experiment, cannot proceed without first employing practical enquiry. Such questions are: What is the out-turn of different crops? What is the right amount of seed to use in sowing rice? What quantity of water should be employed in rice cultivation? Does manuring of rice fields pay? Would draining of rice fields be advantageous? What is the relative out-turn of sugar from different varieties of cane? Does continuous growing of sugar-cane pay? Will it pay in the long run to grow a long-stapled variety of cotton rather than the short-stapled varieties generally grown? Is interculture of other crops with cotton profitable? Is the use of bones advantageous?

Lastly, there are points more connected with the introduction of foreign agricultural practice; for example, the possibility of introducing new crops; the growing of new varieties; the acclimatisation of seed; the selection of seed; the making of silage; the use of new implements; the use of litter and preservation of urine; the better conservation of cattle-manure; the reclamation of salty land (*usar*), of ravine and other waste land.

The need of an expert agency.

407. The enumeration of the subjects set out in the last paragraph clearly points to the necessity of having an agency of an expert nature to deal with them. They are not matters which administrative genius, a high intellect, or even ordinary common sense can decide, but which need the application of special technical knowledge of agricultural conditions and practice. This has been recognised alike by the Famine Commissioners, the Government of India, and by individuals qualified to speak on the point.

Opinion of Famine Commissioners and Government of India.

I must here repeat the extract quoted in Chapter I., paragraph 4, from the Government of India's Resolution of December 1881, when commenting on the Famine Commissioners' Report :—

> "The Famine Commissioners have, with great distinctness, intimated "that . . . . a *permanent agency* should be closely associated with the existing authorities in each Province for the systematic prosecution of "agricultural *enquiry*. The importance of this view, which directs attention "to those duties of the Agricultural Department which must precede any "attempt at agricultural *improvement*, has hitherto been far too greatly "overlooked."

The Resolution also says :—

> "The desirability of closely associating the permanent agency thus required with the existing administrative staff is, throughout the Report of "the Famine Commissioners, strongly indicated. The system, they write, "should be worked by the ordinary official staff, supplemented, where "necessary, to meet the special circumstances of the case."

And later :—

> "The Department having thus primarily turned its attention to those "parts of the country in which agriculture is depressed, or its results uncertain, may hereafter give consideration to the general improvement of "agriculture. . . . It may, as time goes on, become the duty of the Department to associate with itself in this investigation the assistance of *qualified* "*experts*."

The Notes presented to the Agricultural Conference at Simla, in October 1890, by the Government of India, the Bombay Government, the Madras Government, the Bengal Department of Land Records and Agriculture, the Poona Agricultural Association, and by Mr. J. B. Fuller, contain references to the need that exists for the employment of agricultural experts.

Note of Government of India, May 1890.

The Government of India's Note says :—

> "Continuous enquiry should be maintained by means of Experimental "Farms or other similar agency, with the view of ascertaining the possible "results which may be gained by the introduction of new, or the modification of existing, processes and practices connected with agriculture."

Note of Government of Bombay, 1890.

The Bombay Government point out that they have appointed a European expert as Superintendent of Farms, and have established agricultural branches of the Colleges at Poona and Baroda.

The Madras Government's Note says :—

> "The experts . . . were chiefly occupied with farm and college duties, "and could not work continuously and closely at the numerous investiga-"tions suggested or thrust upon them from time to time, and which re-"quired the organised staff of a Department."

Note of Madras Government, 1890.

The second of the Madras Government recommendations (the first being the institution of a careful and definite system of enquiry into existing practices) was, "the inauguration of "experiments under the control of *trained agriculturists.*" And it was suggested that "a certain number of agricultural "inspectors should be employed on a careful and minute "study of agricultural practices, their work being carefully "directed and supervised by European experts." In addition to having the present Assistant Director of Agriculture, it was resolved to apply to the Secretary of State for a second European *expert* to be primarily employed in investigations into the methods of agriculture followed in the various parts of the Presidency, and to attach two of the agricultural inspectors to this officer.

Note of Bengal Department of Land Records and Agriculture, 1890.

The Bengal Department of Land Records and Agriculture, which was only started in 1885, recognised at the outset the need of agricultural enquiry, and employed two or three of the Assistants in the Department who had made a study of agriculture in England, to enquire into the systems of a few of the most important districts in the Presidency. The Reports on the Agriculture of Dacca by Mr. Sen, and on that of Lohardaga by Mr. Basu, were outcomes of this policy. The subsequent usefulness of the special officers was, however, greatly destroyed by their transference to other Departments, or their employment in purely office work.

Note of the Poona Agricultural Association, 1890.

The note of the Poona Agricultural Association advocates the placing of Provincial Farms under the management of "a European well trained in the theory and practice of agri-"culture and horticulture, and having Indian experience," and adds that he should have "one or two native assistants "under him educated in Indian agricultural schools, and pre-"ferably belonging to the agricultural classes."

Mr. Fuller's note, 1890.

Lastly, Mr. J. B. Fuller, in his Note, says :—

> "Much success . . . cannot be hoped for unless Agricultural Depart-"ments are officered by men who are not only trained in agricultural "science, but also have an intimate acquaintance with Indian agricul-"ture. . . . Very little success can be expected unless a permanent "*technical assistant* is attached to each Department."

408. From the time, accordingly, when the improvement of agriculture was first seriously considered, until the present time, there has been a strong expression of opinion, in which I fully concur, that the work is one which requires a *permanent agency,* and the assistance of men possessed of the requisite *technical knowledge.* Agriculture is a distinctly technical subject, and no one without a special training in it can be expected to deal successfully with it.

The present agency.

At present the only agency that exists is the Director of the Department of Land Records and Agriculture in each Province, together with his office staff. The latter, with few exceptions, are men who have had no previous acquaintance with agriculture, either by their early training or by their surroundings, and their duties are mainly those of compiling Statistics and keeping Records. In Bengal, as I noted just now, Assistants to the Director have been appointed from time to time for special agricultural work, but it has not been continuous in character; in the North-West Provinces, in Bombay, and in Madras, Assistant Directors of the Department have been appointed, but all of them have laboured under difficulties, and their principal duties have been those of office work, and not those of a strictly agricultural nature.

The Director of the Department of Land Records and Agriculture.

Coming next to the Director of the Department of Land Records and Agriculture (for this is his correct though somewhat cumbersome title, and not that of "Director of Agriculture," as he is conveniently but erroneously called), it must be at once said that, with rare exceptions, he has not the necessary technical knowledge to fit him for the work of agricultural improvement. The early training of the future Civil Servant is not one which directs his attention specially to, or encourages the pursuit of, Natural Science, but it is rather one of a classical, mathematical, or literary character. After the selection of men by open competition there is no special inducement given to them to study natural science. It is only within the last few years that Agricultural Chemistry has been introduced into the final examination as an optional subject, along with other branches of Natural Science. Briefly, the man whose bent is towards those sciences a knowledge of which would be useful to him later as an Agricultural Director, is at a disadvantage compared with the classic or mathematician. I am well aware of the difficulties which stand in the way of allowing probationers to study agriculture as a special subject before going out to India, and I do not advocate that this should be done, for there are other more important duties for which the Civil Servant has to undergo a special preparation at home. But I mention these matters for the purpose of showing that, up to the time of his landing in India, there is nothing to distinguish the future Agricultural Director from the subsequent Collector or Judge, and that he arrives without having acquired any technical knowledge whatever of agriculture. Not even after arrival in India is the case much better, for all alike pass through much the same course of district work. In this way a man acquires a certain amount of acquaintance with the agriculture of the part where he is placed, but it is mainly with the work of the court-house (*cutcherry*) that his time is occupied. Later on, administrative and magisterial duties have the first claim upon a Revenue officer, and, unless it should fall to his lot to be entrusted with the Settlement of a district, he hardly comes at all into close relations with the agricultural practices and conditions of the part where he happens to be. An acquaintance with agriculture is, as a matter of fact, no necessary qualification for the appointment of Director of Agriculture, nor would a man hesitate, on the ground of his not having any special knowledge of agricultural matters, to accept such a post, were it offered to him. So it comes about, and the past history of Agricultural Departments abundantly shows it, that the Directors are simply men of administrative ability, taken out of the regular Revenue line, for one reason or another, but *not* of necessity because they have shown any aptitude for dealing with *agricultural* questions, or because they have any special leaning towards the pursuit of Natural Science. The consequence is that, too often, after their appointment, they are brought face to face with subjects which require technical knowledge for handling them aright, and the absence of this knowledge leads to the practical neglect of the more strictly *agricultural* duties of the office. There are other reasons, too, for this neglect. The administrative duties of the office are numerous and varied; there are Land Records to be kept up, and the work of inspection of village accountants (*patwaris*) to be done, so that, with these and the necessary office work, the Director has but little time to give to the study of the details and systems of agricultural practice, or to the possible improvement of agriculture which may arise from that study. Some Directors of Agriculture, indeed, have openly avowed their intention to confine themselves to the work of Land Records, and *not to attempt* the larger one of agricultural improvement. Thus, in effect, the Director becomes what he is strictly defined as being, viz., the Director of the Department, rather than what the holder of such an office should be, viz., the Director, or, better still, the Commissioner, of Agriculture. The agriculture of the country can hardly be said to be capable of being *directed*, but the oversight of it in a Province may be *committed* to the care of an individual.

From having, therefore, his time fully occupied with administrative duties and with other work, but mainly from not having the technical knowledge which may fit him to deal with agricultural questions, the Director of the Department is, in most cases, obliged to leave the work of agricultural improvement alone. It is significant to note that in January 1878, subsequent to the appointing of a Director of Agriculture and Commerce in the North-West Provinces, application was made to the Secretary of State for an Assistant to the Director, on the ground that "the discharge of the "duty devolving on the Director requires the possession of "qualifications which cannot be acquired without special "training."

It would not be right, however, were I to pass without acknowledgment the good work that has been done by some few members of the Covenanted Service who have held the position of Director of the Agricultural Department of their respective Provinces. But, when I come to examine the individual cases to which I refer, I find that in every instance the success has been the outcome of an innate love for Natural Science, and more especially for those branches of it which are most closely allied to agriculture, or from their having already possessed some practical acquaintance with agriculture. Unless one or the other of these elements be present, I fear that success will seldom follow even well-intentioned efforts.

A further hindrance to progress is met with in the frequent changes which take place in the occupancy of the Directorship. A Director no sooner has got his staff into working order, and possibly has entered upon some line of enquiry, or commenced some protective measure against famine, than he is liable to be called away to fill some higher post, while his successor may have no sympathy with his efforts, and may allow them to lapse. In this way the work of Agricultural Departments has largely been the result of spontaneous efforts of individuals rather than of one continuous system of enquiry maintained throughout. Continuous enquiry cannot be carried on without a *regular agency* for the purpose, and so long as it is entrusted to men whose tenure of office has no element of permanency about it, the results will be disappointing. I might mention the reclamation experiments at Awa and at Jhansi (*see* paragraphs 70 and 75), as instances of enquiry begun but not concluded, in consequence of changes of the kind alluded to. So also might it be at any time with respect to the ravine reclamation carried on at Etawah (*see* paragraph 70), the *usar* experiments in the North-West Provinces (*see* paragraph 75), and other similar work.

Agricultural experts.

409. Technical knowledge of agriculture is, we have now seen, the missing element in the existing agency of the Departments of Land Records and Agriculture. I shall, therefore, proceed to consider how this lack of technical knowledge can be best supplied.

It has been maintained by some who have turned their attention to this subject that, so long as the interests of agriculture are entrusted to Departments constituted as the present ones are, with a Civilian at the head instead of a practical agriculturist, no good can be done. It is argued that, just as in the case of the Geological Survey, the Botanical Department, the Meteorological Department, and others, the man who is the Director should be an expert in the particular branch, and that Agriculture should form a Department quite separate from that of Land Records. The Director and the Assistants being expert men, they would, it is said, be far more likely to work out some improvement in agriculture than the present organisation.

I fully allow that there is a great deal to be said in favour of this view, and were the circumstances of India different from those which exist at present there would be much to recommend it. Undoubtedly men trained in agriculture, and with a knowledge both of its science and its practice, would be much better qualified to deal with purely agricultural questions than the ordinary Civilian Director, just as it needs a geologist to deal with geological subjects, and a chemist with chemical ones. Could everything be reconstructed, and the whole system of administration in India be altered, this change would be one that I should recommend, but at the present time I cannot see that it is a feasible proposal, and so I do not advocate it. My work is to suggest what *can* be done rather than what *ought* to be done, and it is not for me to propound schemes which cannot, at present at least, be carried out. Besides this, agriculture stands on a different footing to sciences such as geology, botany, chemistry, &c. The truths of these sciences hold good everywhere alike, and the phenomena may be studied in whatever district they present themselves, without any direct reference to the people of that district. An officer of the Geological Survey, for instance, may pursue his enquiries equally in the gold mines of Mysore, the ruby mines of Burmah, the coal measures of Bengal, or the oil districts of Beluchistan. He need be confined to no one locality, but may be drafted in succession to each, and thus have no particular head-quarters. But whenever one attempts to deal with agriculture, he is brought at once into close relation with the people, their habits, their condition, and mainly their relation to the State as the supreme landlord. All questions of agricultural improvement touch upon the circumstances both of the people and of the State, and it is impossible to divorce the two. Wherever he goes, the agricultural enquirer, as I know from my own short experience will be brought face to face with matters in which, not agricultural matters alone, but also the administration of Land Revenue is concerned. The Famine Commission recognised that agricultural progress was bound up with considerations of a Revenue character, and for this reason they did not recommend the formation of an Agricultural Department administered by experts alone. They hinted rather that it might be found necessary to associate with the Department the assistance of qualified experts. This is the opinion which I hold, too, although I would more strongly press the *absolute need* of obtaining this expert knowledge without delay. There are, as I have pointed out, duties other than those of being practical agriculturists which fall to the share of the Director of an Agricultural Department, and which could not be discharged by experts alone. Besides this, unless the agricultural expert be in complete touch with the Revenue authorities, and unless he have placed at his disposal the services of the Revenue subordinates, his progress in the way of agricultural improvement is hardly likely to be facilitated, or his position become an enviable one. On the other hand, if he proceeds to his work under the authority of the present Director, and in harmony with the Revenue authorities of a district, he is likely to be provided with all facilities in making his enquiries. These may seem points of small importance to one unacquainted with India, but to anyone who knows the country they are very material considerations. I must take India *as it is* and not as I think *it should be*, and my endeavour is, therefore, to graft improvements upon existing systems, rather than to suggest the subversion of the latter.

After giving much attention to this subject, I have come to the conclusion that the want of technical knowledge in the existing agency can best be supplied by the employment of *agricultural experts*, such as were contemplated in the recommendations of the Famine Commissioners and of the Government of India; and which are also indicated in the several notes presented to the Agricultural Conference at Simla, in October 1890.

If with the Director were associated one or more Assistants who were trained experts in agriculture, and whose duties would be purely agricultural, the lack of technical knowledge in the Department would be supplied. It would be necessary that these experts should not be hampered with the routine of office work, but be free to pursue, under the orders of the Director, the practical work of enquiry. With the help of such an Assistant or Assistants the administrative ability of the Directorate would be supplemented by that knowledge of a special character which is required to enable it to deal with practical questions, as well as to carry on a continuous system of enquiry and, possibly, of experiment. The regulative skill and administrative qualifications of the Director would still be employed in seeing that the time of the Assistant was being usefully employed, and both enquiry and experiment would form a part of the work of the Department, thus constituting it in reality one, not of Land Records only, but also of Agriculture. Under the orders of the Director it would be possible, by a careful study of the requirements of a particular district and of its agricultural practices, to effect a transference of method from one part to another, or to introduce a new crop, or, perhaps, a new implement, and to pursue the other enquiries which I have sketched out in the earlier part of this chapter (*see* paragraph 406).

In this way I believe that the Department might be made of really practical benefit to the cultivator, as well as a necessary administrative branch of the Executive. It must, however, be clearly understood that to carry this out efficiently an Assistant must be free to employ his whole time in this work, and to pursue it among the people themselves; it would be inadvisable to have an enquiry conducted merely during the intervals of leisure from office duties, for, an enquiry once begun, must be continuous throughout. The men who are appointed must be those who would take up the study of agriculture as the business of their life, meaning to devote their whole attention to it. One fault of the past has been that when Natives have been employed in agricultural work they have not been taken from the right classes, nor have they had the training best fitted for them, so they have not regarded agriculture as their profession at all, but have waited for their chance of obtaining an appointment in some other branch, or of turning to the Law. Agriculture ought to be a distinct profession, and the man who enters it should prepare for it, intending to devote himself to it in just the same way as the Forest Officer enters the Forest Department or the Engineer the Public Works Department; that is, with the intention of remaining attached to that service. Agriculture, on the contrary, has had no permanent agency to carry on its work, and no staff of native subordinates who have been trained in it, or encouraged to continue in its pursuit.

Should agricultural experts be Europeans or Natives?

410. The question now forces itself upon consideration: Ought the agricultural experts to be Europeans or Natives? Without attempting to lay down a rule to be followed in all cases alike, I would indicate my opinion that they should, by preference, be Natives, and Natives trained in India, not in England.

Frequent have been the attempts to provide the expert possessing agricultural knowledge; first, by sending home to England selected Civil Servants, to enable them to qualify, by a study of agriculture at Cirencester or elsewhere, for the Agricultural Directorship on their return; then by sending Natives who have graduated in the University, and allowing them to study agriculture in England, in the belief that on their return they would make useful agricultural officers. But neither plan has worked well as a whole, though in the case of the Civil Servants it must be said that they have fully justified their selection, and have shown the good results of the instruction given to them. But the study of agriculture at a College does not constitute a man a practical agriculturist, and unless the instruction be followed by practical experience on a farm it is not complete. Again, a man has to learn Indian and not English agriculture, and this cannot be taught at an institution like Cirencester College. There are further difficulties in the matter of furlough, and in the changes in tenure of the Director's office, which make it only occasionally desirable to equip a Civil Servant in the regular line with such special training in agriculture as would be obtained by a two years' residence at an Agricultural College in England. On these grounds, and because of the duties of the office being also largely administrative, I do not think it generally feasible to have the Director himself an expert agriculturist.

Some of the arguments advanced tell also against the employment of European expert assistants. They may have a knowledge of English agriculture, but if they begin to apply what they know, before they have studied the conditions of Indian agriculture, they will but repeat some of the many blunders which have made people in India doubt the possibility of improving Indian agriculture at all through the agency of English experts. It is true that in most cases the right men have not been sent out, and that the first lot of agriculturists (so-called) were nothing more than gardeners, and unacquainted with agriculture. But, whether from this cause or from others, a disbelief in the expert has, anyhow, been begotten. Other men of a very different stamp, such as Mr. Robertson and Mr. Benson, have been brought to Madras, and have laboured there under circumstances of, it must be said, a very discouraging nature, for they have received neither the sympathy nor support of their Government, and have been the victims of a continual change of policy on the part of that Government. Duties of office work, or of a tutorial nature, have prevented them from devoting themselves to strictly agricultural work, whilst a zeal on their part to introduce new implements and new methods has not been always moderated with the necessary caution in applying English to Indian agriculture. An Agricultural Department, the Director of which is purely a Revenue man, and who does not spend a certain portion of each year in camping about in his Province, hardly likely to be in full sympathy with efforts made to improve the agriculture, and so it has proved to be the case in Madras. Now, at length, the conclusion is arrived at that it is first necessary to learn more about the methods of Indian Agriculture, and the Madras Agricultural Committee of 1890 have recommended the employment of experts to engage in the work of direct enquiry.

The chief points gained in selecting Natives as experts instead of Europeans are, firstly, that they start with great initial advantages in knowing the language, the habits of the people, and (if they be wisely selected) the conditions of agriculture and the methods employed; secondly, that the selection of Natives would be very much more economical. The advantages with which a Native starts are those which it would take a European a long time to acquire, and the latter would probably never be so closely in touch with the people as the Native expert. Occasionally it may be desirable to have one European expert Assistant to the Director, but this will be guided much by financial considerations, and, if only the proper training be provided, I consider that the work may be done quite well by Natives. If a European be selected he should be a man who has gone through an agricultural course of training, such as is provided at Cirencester, Downton, or other agricultural College, but supplemented (and on this I would insist) by practical experience on a farm. In the matter of salary the procedure adopted by the Forest Department with the men who pass out of Cooper's Hill College and who join the Forest Service might be followed, a similar rate of pay and increase, according to time of service, being given.

Where should they be trained?

It is, however, in the end, to the Natives that we must look to carry out the work of agricultural enquiry, and it becomes, therefore, important to consider how a training in agriculture may be imparted to them. This subject will occupy a subsequent chapter in my Report. Suffice it to say here that I am distinctly in favour of giving an agricultural education in India, rather than of sending Natives to England to study. Past experience has shown that the men selected for a European training have not been those whose associations and interests have been with the land, but they have been men of literary inclinations, who have graduated with distinction at the Universities. Their sharp intellect and wonderful facility in picking up any subject to which they devote themselves have made them apt students of the literature rather than of the practice of English agriculture, and in most cases they have tacked on a study of Law to that of the subject to acquire which they were sent over to England at Government expense. On their return to their country they no longer live as they used to, but adopt European ways and costume, more or less, and become generally discontented with the position which they occupy. In short, the residence in England has had the effect of spoiling them for occupying the position in the Agricultural Department for which they were intended to qualify, and they take the first opportunity they see of becoming "pleaders" in the Courts. In this way the expensive education given to Natives sent home to England is, as a rule, lost to the Agricultural Department, while those who still remain connected with it are dissatisfied with their position and prospects.

Training in India preferable.

On these grounds, therefore, I strongly advocate a training in India for Native experts.

The number of Assistants.

As to the number of Assistants which a Director would require, this must vary in different Provinces, and according to the work to be done, but one for each Division would probably not be more than would eventually be found useful. As the essence of success turns upon the acquirement of local knowledge, the Assistants must of necessity be provincial, and not be removable from one Province to another like the Director.

I would add here that care should be taken in the selection of experts, so as to choose, as far as possible, men from the agricultural classes, and such as have an interest in the land, and who have lived amid agricultural surroundings. Too often men have been taken from the ranks of those who, as a rule, follow the profession of the Law, and who do not regard the pursuit of Agriculture as in any way a profession.

Views of the Agricultural Conference at Simla, 1890.

411. I have now discussed in considerable detail the question of the employment of agricultural experts, and would conclude by mentioning that when I submitted my views (subsequently only slightly modified) to the Agricultural Conference at Simla, in October 1890, they received a very general approval, expressed in the terms of the two following Resolutions passed at the Conference:—

First.—"That, in the opinion of this Conference, it is "essential, for the proper performance of the duties demanded "from the Agricultural Department in the direction of agri-"cultural improvement, that the Director of the Department "should be provided with an Assistant or Assistants who are "experts in the practice and theory of agriculture."

Second.—"That it will be preferable to train Natives to be "qualified for the post of Assistant in the Agricultural "Department in this country rather than in Europe, and that "this end cannot be attained unless there be a high-class "education established in this country."

CONCLUSIONS.

CONCLUSIONS.

412. Before any real improvement can be effected in agriculture, the institution of organised enquiry into existing methods and conditions is absolutely necessary. Thus far, little more has been done than to collect statistics and information as to the liability of districts to famine. The expressed opinions of the Famine Commissioners and of the Government of India have clearly indicated that more than this was intended, and that enquiry into agricultural practices was recognised as a preliminary to agricultural improvement. The time has now arrived when practical agricultural enquiry should be initiated. The principal directions in which enquiry should proceed are, firstly, the obtaining of definite information as to the requirements of each district in the matter of supply of water, manure, wood, and grazing; secondly, the study of agricultural practices, with a view to the transference of the better methods to districts where they are not known.

The agency which Agricultural Departments possess at present is inadequate to carry out such a system of enquiry, and a technical knowledge of agriculture is a necessity.

The Directors of Departments of Land Records and Agriculture are principally occupied with administrative duties, and have neither the time nor the technical acquaintance with agriculture which would enable them to devote themselves to the subject of agricultural improvement. Further, the constant changes in the tenure of the office of Director prevent the continuity of any experimental enquiry.

While, for administrative reasons, it is desirable to retain the Director of an Agricultural Department in his present position, the want of technical knowledge of agriculture must be supplied; this can best be done by associating with the Director one or more expert Assistants who will make agriculture the business of their lives, and whose duty it will be to investigate, under the Director's orders, the agricultural conditions of the different districts of a Province. The men selected as agricultural experts should be, by preference, Natives who have been trained in India.

RECOMMENDATIONS.

RECOMMENDATIONS.

413. That a definite system of organised Enquiry into agricultural conditions and practices be instituted forthwith.

That a Permanent Agency be established for this purpose, and consist of the association with the Director of the Department of Land Records and Agriculture of an Assistant or Assistants who are trained experts in agriculture.

That such experts be, by preference, Natives of India, and be trained in the country itself.

That high-class Agricultural Education be provided in India so as to train the men who are to become agricultural experts.

CHAPTER XVII.

SCIENTIFIC AGRICULTURAL ENQUIRY.

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The connection of science with practice.

414. THE important services which science has rendered to agriculture are now universally recognised, and the marked development of agricultural knowledge during the last half-century is the direct outcome of the application of science to practice.

It is the domain of science to explain the principles which underlie good practice, and to extend the application of these principles, as well as to make fresh discoveries that may be of benefit to agriculture. The work of improvement, had it proceeded simply from the practical side, would have been, as it has always been, slow; but when science set to work to find out the causes of well-ascertained facts in practical agriculture, progress at once became rapid.

The application of science to practice may be briefly described as " the accurate knowledge of facts and the discovery of their causes." When the underlying principles have been discovered, science can apply these to further developments of practice, and to new discoveries. I might briefly illustrate the importance of scientific investigation in regard to practical agriculture by referring to the difference between the state of our knowledge at the present time and that which existed prior to the introduction of scientific enquiry.

The results of combining science and practice.

Formerly, it was enough to know empirically that certain practices were good, that certain kinds of soil were suited to particular crops, that certain foods were useful for cattle, but no one could say more than that these things *were* so, and not *why* they were so. Now, however, the connection between soil, air, plant, and animal has been worked out, and our knowledge is being continually added to; we know, in great measure, what plants are composed of, whence they draw their nourishment and in what forms it must be supplied to them, what the constituents of food are, and the changes which they undergo in the animal economy. We are enabled thus to provide for the needs of field crops by suitable manuring, to repair the demands made upon the soil, to feed stock on a rational system, and to cultivate the land on other than stereotyped lines. Distant countries have been put under contribution to supply manurial resources for our crops and food for our stock. In short, a definite knowledge of the processes taking part in the practice of agriculture has been obtained through the medium of scientific enquiry. At the present time an enquiry is going on which is of the highest importance to practical agriculture. I refer to the possible assimilation of the nitrogen of the atmosphere by ertain plants. The establishment of this theory will go a ng way to explain much that has so far not been understood agricultural practice, and may also have important bearing pon the practice of the future.

Practical enquiry will always be needed to keep up the nowledge of what is being done, and to provide a field for cientific enquiry; but it is, nevertheless, from the latter that, vherever it is possible for development to take place, any great future advance will be made.

The special conditions of India limit the field of scientific enquiry.

415. The above remarks have been made in reference to agriculture in general, and not to Indian agriculture in particular. I have shown, indeed, in earlier chapters, that the conditions of agriculture in India are such as to greatly limit the possible scope for improvement, and, consequently, to narrow the field for the application of scientific enquiry. As Mr. Thiselton Dyer points out, the history of agricultural progress in Britain shows it to have had its origin mainly in the existence of a class of landowners who had intelligence to attempt the work of improvement by the application of the teachings of science, and also wealth to carry it through; but the poorer tenant farmers would never have *initiated* such enquiry, although they were not slow to adopt its results when they saw that it *paid*. The non-existence in India of any class corresponding to the resident English landowner of intelligence and wealth is a bar to the progress of original agricultural investigation, and will limit the pursuit of enquiry to such matters as seem to have a direct bearing upon the immediate well-being of the people. Further, the smallness of the holdings, the paucity of capital, the habits and prejudices of the people, and the financial obligations of the Government, are bound to impose obstacles which would not present themselves to such a degree in other countries.

Scientific method in enquiry necessary.

416. Nevertheless, adopting even this restricted view of the possibility of applying the results of scientific enquiry to agriculture, there are abundant reasons for its not being neglected altogether, and for advocating its pursuit whenever practicable.

Primarily, let me say that, if practical enquiry is to be successful, it must be scientific in its methods, it must proceed on a well-regulated plan, and its results must be submitted to careful and critical examination. The mere collection and record of facts is not enough; they must be put into a connected and useful form, and they must be verified by experiment. Such work as this cannot be adequately performed without the possession of a scientific training of mind by those to whom it is entrusted. So far as India is concerned, I regard the proper regulation of practical enquiry, and the examination of its results, as one of the most useful ways in which scientific knowledge may be applied to the practice of agriculture.

The relation of chemistry to agriculture.

417. While acknowledging the bearing of sciences such as Botany, Geology, Physiology, Engineering, and Meteorology upon agriculture, it is Chemistry more than any other tha has been productive of the greatest results to agricultur in the past, and from which, as coming most in contact with agriculture, the greatest benefit may be expected in the future.

Moreover, it is with the application of chemistry to the improvement of Indian agriculture that the present Report is largely concerned.

Such rapid strides, however, has the science of chemistry made within recent years, and so widely has it ramified into almost all branches of industrial occupation, that agricultural chemistry, or the application of chemistry to agriculture, has become a branch by itself, involving separate and special study. It will be my business, in the remarks that follow, to see how agricultural chemistry may be most usefully brough to bear upon the improvement of agriculture in India.

Opinions as to the desirability of having an agricultural chemist in India.

418. The need of bringing in the aid of agricultu chemistry to the problems of Indian agriculture has admitted on many hands, though nothing special has been done to supply it. I might refer to my first cha where, in paragraphs 5, 7, and 8, are mentioned the repeate plications both of the Government of India and of Agricult Conferences for the appointment of an agricultural chemis India. Mr. Medlicott, when Director of the Geological Su vey, writing in 1877 upon the "Reh" enquiry, said:—

Mr. Medlicott, 1877.

> "Observation and experiment cannot be profitably made by men, how- " ever otherwise intelligent, without any scientific knowledge of the matter " under investigation. I would therefore advise that a well-qualified " agricultural chemist be engaged . . . under the Department of " Agriculture to devote himself to this special investigation."

Government of India, 1881.

The need of an agricultural chemist was foreseen by the Government of India in 1881. In their Resolution of December 1881 they said:—

> "Finally, the science of agricultural chemistry will be demanded for the " solution of many important agricultural problems."

Government of India, 1883.

In 1883 the Government of India formed a strong opinion that there should be an agricultural chemist for the Northern Provinces, and mentioned the vast unculturable tracts that existed on account of the occurrence of soda salts which impregnated the soil. They considered that the aid of science might reclaim these lands. Consequently, in their Despatch of 8th February 1883, they asked the Secretary of State to sanction the appointment of an agricultural chemist who could be used for this work and for educational purposes as well. It was proposed to establish an Agricultural College in the North-West Provinces, and to attach an agricultural chemist to it. The Secretary of State refused the application on the ground that the matter was a provincial and not an imperial one.

Government of India, 1884, 1886, 1888.

Successive recommendations for the appointment of an agricultural chemist have been made by the Imperial Agricultural Department in 1882, 1884, 1886, and 1888, and have each time been supported by the Government of India. The Secretary of State, however, while allowing the importance of the matter, has expressed himself as not satisfied with the methods proposed.

Agricultural Conference, October 1890.

The Conference of Agricultural Directors at Simla, in October 1890, expressed their opinion that there were an enormous number of questions which they (the Agricultural Directors) wanted to be answered, and which only a chemist could answer . . . "it was self-evident that an agricultural " chemist was needed for India, just as the Royal Agricultural " Society of England found that one was needed for them " . . . a chemist was needed for investigation, and as a " referee, quite apart from the question of education."

Sir Edward Buck, 1890.

Sir Edward Buck, in conversation with me, succinctly stated his opinion that all attempts at agricultural improvement must have for their basis some scientific groundwork, and as chemistry is the science that comes most in contact with agriculture, he considered that an agricultural chemist, to act as an agricultural expert, is the man most needed and most important.

Scope for work of an agricultural chemist.

419. In the preceding chapters I have, when dealing with each subject in detail, taken occasion to point out where the assistance of an agricultural chemist could be usefully employed. I have instanced several matters of agricultural import which await investigation because of the want of a man with special knowledge of agricultural chemistry, and who could deal with them on the spot. Among these are the following: the possible exhaustion of the soil by the present mode of cultivation, and the export system; the sufficiencies and deficiencies of different soils in respect of the various soil constituents; the nature of alluvium and black cotton-soil; the influence of over-irrigation upon the soil; the amount of nitrogen in the rainfall; the fixation of atmospheric nitrogen by the *Leguminosae*, and possibly by other plants as well, and their influence in restoring the soil's fertility; the nature, origin, and removal of saline deposits (*reh*); the differences between canal water and well water; the composition of various kinds of well water; the composition and use of different manurial substances, and their applicability to particular crops; the discovery of fresh manurial supplies; the better preservation of cattle manure; the explanation of the *ráb** system; the composition of food products, and the relative values of different fodders; the nature of native clarified butter (*ghi*) and other dairy products; the causes which affect the out-turn of sugar; the investigation of the chemical changes

Scientific investigation.

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* *See* footnote page 27.

which take place in the manufacture of indigo, and the parts they respectively play in influencing the produce; the examination of suggested improvements in indigo manufacture; the influence of manuring upon the cultivation of tea; the investigation of the processes employed in the manufacture of tea; the manurial treatment of coffee; the curing of tobacco.

Association of chemist with practical enquiry and experiment.

420. But there are other duties which an agricultural chemist would be called upon to discharge, and these, while somewhat of a different nature to the above more independent and scientific investigations, are of great economical importance in the progress of agricultural enquiry and experiment. I allude chiefly to the work of planning, regulating, and watching practical enquiry and experiment, and of critically examining and systematically recording the results obtained. My own experience has abundantly shown me that, though the undertaking of a practical enquiry or of an experiment in practical farming may appear at first sight a simple enough matter, it is the general fate of all such efforts to fail, or to fall short of the full benefit they might confer, whenever there is an absence of scientific design, supervision, and examination. I do not say that it is necessarily an agricultural chemist that is required, for, indeed, a man who is purely a "laboratory man" or, in other words, nothing but a skilful analyst, but who has not also an acquaintance with the details and requirements of agricultural practice, will not be at all a suitable person to select. But it is rather the man of a scientific turn of mind, and able to appreciate where science can be usefully applied to practice, who will be best fitted for undertaking the work of enquiry. It will not be long, too, I think, before he finds that he has to call in the assistance of more specially chemical experience to aid him. If, then, in one person can be combined both the chemical skill and the appreciation of the practical points involved, the most suitable man is found. I have often examined so-called "practical" experiments, which have failed because the plan was not devised so as to lead to any definite or satisfactory conclusion, or because there was not that critical examination of the results which would enable a right conclusion to be drawn. In these details of practical enquiry and experiment the assistance of an agricultural chemist would be of undoubted service.

Illustrated by *usar* enquiry.

I have in an earlier page referred to the experiments on reclamation of salty land (*usar*), and have stated my belief that chemical science should have been employed in the enquiry. It should have been known, for example, not only that the land in question was "salty," but also to what extent it was "salty;" to what depth the saltness extended; to what particular salts it was due; what the surface water was, and what the subsoil water. Then, again, to what extent the various reclamation processes respectively succeeded in removing the injurious salts; what quantities of the salts proved harmful, and at what point the reclamation might be considered effected; whether the various salts were equally injurious or not.

Enquiry into canal and well waters.

Again, I mentioned the enquiries made as to the respective merits of canal and well water. No chemist would have thought of speculating vaguely as to what the temperature of either water was, or whether one contained abundant lime, and the other not, when there existed for him ready means of absolutely determining the questions raised.

Methods of butter-making.

To take yet another instance, in Chapter XI., paragraph 264, I spoke of the competitive trials instituted, at the time of Mr. Howman's visit, between Native and European methods of butter-making. That the Native manipulators succeeded in obtaining a larger weight of butter from the milk given to them showed no more than their cleverness in incorporating with their butter a great deal of water, while Mr. Howman's butter was free from any excessive quantity. It also left undetermined whether all the native-made butter was pure butter, or had some amount of curd with it. These are points where the help of the chemist must be brought in, and which can only be satisfactorily decided with his co-operation.

Experiments on Government Farms.

Many have been the experiments carried out at Government Farms and elsewhere on the use of different manures, but, though to the practical man it may be enough to determine, possibly, whether this particular material is better than that, the chemist would not be satisfied with the limited results from such enquiry, results, too, which would have to be repeated each time anew as a fresh material came before his notice. If, however, he can get at the principle or *rationale* of manuring, and can ascertain *what* it is in each material that produces the result, then the chemist can apply the knowledge he has gained to the utilisation of other materials containing like properties.

The association of a scientific adviser with experimental enquiry would, without question, result in restricting both experiment and expenditure to more useful ends than has altogether been the case in the past.

Examination of results of enquiries.

It is very desirable, also, that the information to be conveyed by practical experiment should be set out systematically in a form in which it may be intelligible and useful. The bare record of what has taken place, the harvest results merely stated *en masse*, or, what is perhaps even worse, the drawing of conclusions from each experiment without relation to what has gone before, are only likely to lead to the accumulation of tables and literature which no one will attempt to wade through. A single experiment conducted simultaneously at four or five different places, and under varying conditions, is likely to lead to the acquirement of more solid knowledge than is the attempt to collate some 30 or 40 results at one experimental spot. It needs, therefore, someone who shall adopt a scientific and critical method, and be able to look beneath facts to the principles that underlie them.

The need of continuity in experiment.

421. Perhaps one of the chief needs of agricultural experimental enquiry is to have someone associated with the enquiry whose recognised duty it shall be to *preserve the continuity* of experiment. How often could it be said of agricultural experiments in India that they had failed simply because there was no one whose *duty* it was to look after them, to see that they were maintained, that the results were duly recorded, and that they were made available for use! How many have been the men, who, eager to do something towards agricultural improvement, have begun this work or the other, and then have been transferred to some other district or Province, leaving their task to a successor who in all likelihood has not had the least interest in it, and so has let it drop altogether! This is the general fate of agricultural enquiry in India, and it will always be so until a *continuous and responsible agency* is substituted for the present system of spontaneous and amateur effort. In this way the Awa experiments on *usar* reclamation (*see* paragraph 75) failed, and such might be at any time the history of every work of experimental enquiry or every Experimental Farm. Good work has been begun, but no one has been charged with the oversight of it; it has been always a matter of personal choice and inclination, and what has been no one's duty has, after a time, too often been neglected and lost sight of. An agricultural chemist of the type I have suggested might, on the contrary, be definitely charged with the duty of maintaining the continuity of experiment, of watching its progress, of suggesting its development, and of examining and collating its results in useful form. In some such way alone can experiment be carried to a successful termination, and the work is one which might well be conducted by a man possessing a fair practical knowledge of agriculture combined with a more special one of chemical science and scientific methods.

In the course of my tour I went to see an experiment on the reclamation of ravine land by means of embanking (*bunding*)* it, so as to hold up the water, and thus provide water and irrigation. Wells were hard to dig, the water-level being low and the ground rocky. One object of the enquiry was to see if the water-level of the country would be raised by the embanking of the land. On enquiring whether any rise had resulted, I found that it was impossible to tell, for, either the level at starting had not been taken, or, if taken, it had not been recorded; at all events, no one at the Station knew about it. This does not require a chemist, it is true, but it is an instance of what will happen over and over again in India unless work of enquiry be entrusted to men of a scientific turn of mind, and also be put in the hands of a *continuous* and *responsible* agency, and not be left to amateur and spontaneous efforts.

The need of a "referee" or "scientific adviser."

422. Another function which an agricultural chemist of standing could usefully serve would be that of acting as a "referee" or "Government adviser" in chemico-agricultural matters. There ought certainly to be someone in India who would be able to give an authoritative opinion on points where the relation of chemistry to agriculture is concerned. The advantage to Government of having someone to whom they might confidently turn for guidance in chemico-agricultural matters, involving, as they often do, very considerable expenditure, needs no demonstration. Nor, again, is it necessary to explain how very useful such an adviser would be to the Agricultural Directors of the different Provinces. Without having the power of interfering in any scheme initiated by an Agricultural Director, the "adviser" would be available if the Director wished to seek his guidance, alike in commencing, conducting, and usefully summarising the results of any experimental enquiry.

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* *See* footnote page 31.

Chemical knowledge of food products, &c.

Associated with such an office would be the duty of adding to chemical knowledge respecting the food products, crops, and other resources of the country, a work which has, so far, been but very imperfectly done.

An agricultural chemist in connection with educational work.

423. Lastly comes the need of having an agricultural chemist in connection with the development of Agricultural Education. Though not proposing, as I shall presently show, that the suggested "scientific adviser" should be himself directly charged with the work of teaching at any fixed centre or centres, I nevertheless consider it very desirable that he should supervise such instruction as is given, and be responsible for its proper conduct. Let me say at once that, while I hold the teaching of Agricultural Chemistry as a special branch of science to be a desirable part of a general scheme of Agricultural Education, I by no means wish it to be regarded as indispensable for agricultural improvement under the conditions that exist in India. That there should be someone who has a good and practical knowledge of Agricultural Chemistry I certainly consider a necessity; but I do not imply that it will be necessary to spread instruction in that particular branch of science in order to achieve any success. The mere teaching of Agricultural Chemistry will not in itself create agricultural prosperity, though it may open the mind, and lead to an understanding of the principles upon which practice is based. In its methods it is explanatory and regulative rather than creative. In India there is great fear that if Agricultural Chemistry be taught as a necessary part of an agricultural curriculum it will be studied in a purely *academical* manner, as an additional subject of a Course. I have had opportunities in England of judging how this is likely to be the case, having had experience as an examiner of Indian students who have come over to study agriculture at Cirencester and elsewhere. With wonderful powers of getting up any subject to which they apply themselves, and with marvellously retentive memories, they are able, by their accurate replies to the questions set them in an examination, to acquit themselves with credit and distinction;

The teaching of agricultural chemistry.

nevertheless, to an examiner who has them before him for *vivâ voce* examination, it is apparent that there is not that practical understanding of the subject, and that grasp of it, which are likely to lead to future benefit as the result of the study. The knowledge which these Indian students possess presents itself to me as that of a subject studiously and carefully got up with the aid of great natural abilities, but which remains merely as an impress on the mind for a time, and which fails when the call comes for its application to practice. Therefore, I do not look for great results to follow at once the introduction of the teaching of Agricultural Chemistry, and I would not suggest that provision be made for it on any large scale at first. Still, I think that there should be one or two places, perhaps, where instruction in Agricultural Chemistry could be given, both theoretical and practical. For the right conduct and efficiency of such teaching, and for its development when called for, the "scientific adviser" should be responsible.

Preparation of text-books.

In another branch of educational work the "scientific adviser" could render useful service. This is in the preparation of a text-book or text-books on Agricultural Chemistry, which shall be specially adapted to the case of India. At present there is no such book existent, and though it is true that the principles of a science remain true everywhere, yet it is in the judicious illustration of principles by practice that the chief value of teaching consists; besides, the conditions and practice of Agriculture in India are so different to those in England as to make the adoption of English text-books undesirable. The "scientific adviser," again, would be able to do good service in an educational direction, not alone in the preparation of a text-book of Agricultural Chemistry, but also in aiding the issue of text-books on Practical Agriculture throughout the different Provinces of India. By the co-operation of the *agricultural experts* (referred to in the last chapter) with the "scientific adviser" a series of agricultural text-books specially adapted for particular Provinces or districts might be issued, and would greatly aid the spread of sound knowledge of Agriculture and of its underlying principles.

Summary of duties of "scientific adviser."

424. The principal functions of a "scientific adviser" in agricultural matters should, it appears to me, be as follows:—

1stly. To act as a referee or adviser to Government in all chemico-agricultural matters.
2ndly. To direct and maintain the continuity of experimental enquiry into Agriculture.
3rdly. To compile and publish the results of experiments, and to show their practical bearing.
4thly. To make independent scientific investigation upon agricultural questions.
5thly. To direct the teaching of Agricultural Chemistry, and to assist the spread of Agricultural Education, by the preparation of simple text-books.

The qualifications necessary in a "scientific adviser."

425. I have now explained my reasons for believing that there is call for an agricultural chemist in India, and I have also mentioned what I think his chief duties should be. It becomes now necessary that I should set out in detail some considerations which it is imperative should be attended to, if any good is to result from an appointment such as I have suggested.

In the first place, a man fitted for carrying out the duties indicated above must be a man of high scientific attainments, capable of giving an authoritative opinion on points where Agricultural Chemistry is concerned. He must, accordingly, be especially a good scientific and practical agricultural chemist, able to conduct scientific investigation, and to carry out the practical work of an analytical laboratory. But he must be more than this; it is necessary that he should have a good general acquaintance with practical agriculture. I do not say that he must be a practical farmer, this is not what is required ; but he must have had that acquaintance with it which shall enable him to understand its methods and requirements, and thus usefully to bring his scientific knowledge to bear upon its development; in short, it would not do to have a pure " scientist," or a man who simply buried himself in his laboratory, and carried out investigations which had no direct bearing on Agriculture as actually practised. The investigations pursued should be those based upon the actual practice, and their direct intent is to be the bettering of that practice under *existing* and not under *ideal* circumstances. It would be necessary, therefore, to carry on investigation in the light of an acquaintance with local conditions and requirements. In some ways, then, it is rather the scientific agriculturist than the " laboratory chemist " that is required ; inasmuch, however, as the attainment of high *chemical* knowledge of agriculture is a necessity, and can only be obtained by previous special study (for which the practical agriculturist has not the opportunity) the agricultural chemist is the man primarily needed. He must, however, be one who is able to add to his scientific attainments a good general acquaintance with agricultural methods and conditions. As one of the delegates to the Agricultural Conference at Simla, in October 1890, said, " We want . . . a man " who is at once a good chemist in the laboratory and " acquainted with practical farming on its scientific side ;" this, it seems to me, fairly describes the kind of man who is wanted. He must be a man of business habits and capacity, and also sufficiently practical to be able to supervise experiments, and to go round and see what subordinate officers are doing, whether by way of experiment, enquiry, or teaching.

The number of such men required.

426. The next question that arises is, whether one such man is sufficient, or whether several are required. I am decidedly of opinion that, at the outset, *only one* agricultural chemist is wanted, inasmuch as the scheme must be regarded as more or less experimental. As I have pointed out already, I do not regard the want of an agricultural chemist as *the cause* of the non-progress of agricultural improvement, although I consider its supply to be a very necessary part of the machinery that is to take in hand the work of improvement. Therefore, I would prefer to begin in a moderate way, and not to commit Government to more than a tentative scheme, the further development of which would depend upon the success achieved by the initial one. I do not deny that the suggested scheme is inadequate to meet the requirements of the country and of the different Provincial Governments, but it is all that, under present conditions, I feel justified in recommending, viz., the appointment of one first-class man to act as Government referee and adviser. For a complete scheme it would be desirable, I think, to have an agricultural chemist in each Province, or, at least, in each of the three Presidencies, Bengal, Bombay, and Madras. But it would be better to begin with one man, and if the necessity arose, and the desirability of such appointment were shown, then to appoint others. If one man, accordingly, be appointed, he would of necessity be Imperial, but at the same time available for all Provinces alike. Any Provincial Government which might wish to avail itself of his services would be entitled to do so, and, thus, his functions would be rather national than imperial.

Necessity for extended time and opportunities of study to be given to a "scientific adviser."

427. The third point upon which I would insist is, that if any appointment be made, there must be sufficient time allowed to see whether the experiment (for such I must term it) be a success or not; also, the man so appointed must have time and opportunity given him for acquainting himself with the methods and conditions of Indian agriculture. A man, be he ever so good an agricultural chemist, or be his acquaintance with English agriculture ever so great, is almost sure to fail unless he have given him the opportunity of studying the peculiar surroundings of Indian agriculture. In fact, he will almost have to forget, for the time, what he knows, and start afresh as a *learner*. To attempt to teach or to improve agriculture without first becoming acquainted with its conditions is to court almost certain failure. I am only too well aware that whatever I have been able to gather during my own tour has been the outcome of those facilities which were so readily placed at my disposal, and of which I availed myself with the view of acquiring as much knowledge as possible of the agriculture practised in different parts of the country. But, while the new comer will do well to regard himself for some time as a *learner*, it is equally incumbent on those to whom the giving of such an appointment is entrusted, that they should be content to exercise patience, and that they should allow time for the chemist to get that practical acquaintance with Indian agriculture which is essential to his after success. To bring a man of scientific attainments over to

India, and to set him down to work out plans of experiment, or to engage in investigation, before he knows anything practically of the agriculture of the country, is to ruin the project from the very outset. The history of past efforts at agricultural improvement abundantly illustrate this, and the men who have been located in one spot, and have been set to work out improvements from thence without going about and acquainting themselves with the country, have proved of but small value. The real blame, however, attaches not to them so much as to those who have called upon them to "make bricks without straw," and have asked them to write Reports, conduct experiments, and, in short, to justify their appointment, long before they have had an opportunity of providing themselves with the knowledge necessary for the useful discharge of the duties which have fallen to their share. I may be putting this very strongly, but I am well aware of the need of so doing, for the error is one that has been repeated over and over in the past, and I am anxious that it should not be committed again in connection with the possible appointment of an agricultural chemist. I would, therefore, strongly urge that, unless it be clearly understood from the commencement that a man appointed to such a post shall have the opportunity given him of studying the principal conditions of Indian agriculture, and of acquainting himself with them by means of travel, it would be far wiser not to make any appointment at all. If, however, time be allowed, patience be exercised, and opportunities of gaining experience be given, the proposed plan will have a fair chance, and should it then be found to fail, it will fail either on its merits or because of the deficiencies of the individual. If the former be the reason, it may fairly be said that the experiment has been tried and has failed, and it will remain as an experiment of not too extensive or over costly a nature: if the individual prove unsuitable, he can be replaced. It is not possible to define exactly what number of years should be allowed for the experiment to be on its trial, but the general opinion expressed at the Simla Agricultural Conference in 1890 was, that not a less period than seven years should be named for the duration of the appointment. This appears to me a fair term to fix. It would not be necessary, as it was in my case, that the man appointed should take at the outset a hurried view of the whole agriculture, but it would be quite feasible to select some typical district for special study each year, and to devote a certain time to travelling about to other parts.

The "scientific adviser" is to be primarily an investigator, not a teacher.

428. A necessary part of the equipment of a "scientific adviser" is that he be provided with a laboratory suitable in every way for the carrying out of analytical work and of investigation. This at once opens up the question as to where such a laboratory should be placed, and how the work there is to be conducted. With this is bound up the consideration as to whether the "scientific adviser" is to be directly engaged in the work of teaching or not. This I have in part discussed already, and now state my decided opinion that the "scientific adviser" should be primarily an *investigator* rather than a teacher, and that his time should not be taken up with the routine duties of teaching. If a man is to be the instructor of such students as would attend an Agricultural College, he would of necessity have to be located at some one fixed place, for a part of the year at least, and certain duties of a routine nature would be expected of him. This, in the case of India, would, to my mind, interfere altogether with his usefulness as an investigator, and as an adviser to Government. It is more than probable that his presence would be required in some part far away from his teaching centre just at the time that the course of instruction he was conducting was going on. I am not at all disposed to favour the employment of an agricultural chemist to *combine* the duties of investigator and teacher, but I think that the two functions should be kept quite distinct. The "scientific adviser" should be free to move here and there as might be required, and should not be tied down to any one place in particular.

At the same time, as I pointed out before, he should not allow the work of giving instruction in agricultural chemistry to pass out of his control, but he should direct it, and be responsible for its efficiency. It would be very desirable also that he should, from time to time, as opportunity permits, give occasional lectures, or short special courses of lectures, at different centres throughout the country.

The need of a good laboratory, and of an assistant chemist in charge of it.

429. Although I would not fix any definite centre where the "scientific adviser" is to work, he must clearly have a good laboratory or laboratories at his disposal. There must also be some place or places to which applications may be addressed, and with which he shall remain in communication. Suppose him to be engaged in an enquiry upon salty land (*usar*) reclamation; he may have samples of soil, or of water, or of salts, to analyse in pursuit of the investigation. These cannot be analysed on the spot, but would have to be referred to a laboratory, and be done either by him upon his return, or, in the meantime, by some one working under his instructions. This leads me to consider the desirability of having a second man as Assistant to the "scientific adviser." This I would recommend on two main grounds; firstly, the advantage of having a resident analyst to carry out the details of work conducted in a laboratory; secondly, the advantage of being able in this way to provide for the teaching of agricultural chemistry at certain fixed places.

In the work of investigation and enquiry there will be numerous analyses to be performed, and purely analytical details to be carried out, all involving care, skill, and special chemical training, but yet more or less routine in nature. It is not necessary, nor even desirable, that the time of a highly-paid officer of special qualifications should be taken up with routine matters more than can be helped, but it should be devoted more particularly to that which he alone can do. It is also very desirable that analytical work connected with any enquiry should proceed without interruption, under a fully qualified chemist, although circumstances might require the presence of the head man at a distance from his laboratory. Were all analytical work of this nature to be left until the head man could return, and then had he to carry out all the analytical work with his own hands, there would soon be an accumulation which it would be hard, and often impossible, to overtake, and he would often be prevented, too, from taking up other work that calls for his special employment. If, on the other hand, there were a second man, or Assistant Chemist, as I may best term him, acting under the directions of the "scientific adviser," he would be able to carry out all the analytical details, and present them to the senior chemist for his utilisation on his return, or for forwarding to him if still away. Further, the presence of an assistant chemist resident where the laboratory is, would ensure someone being on the spot, ready to attend to any analytical work required by Agricultural Directors, or for Experimental Farms, or to transmit anything for reference to the senior chemist. A constant communication would thus be maintained between the "scientific adviser" and the laboratory where his work is conducted, as well as with those who might wish to apply to him.

The utilisation of an assistant chemist for educational purposes.

But the second advantage to be gained by the appointment of an Assistant Chemist is also a very important one, inasmuch as it appears to me to provide for the educational want which the Government of India represented to the Secretary of State, and it at the same time meets the very proper objections of those who urged that an agricultural chemist should be used for purposes of investigation, and not directly for teaching. With an assistant chemist resident at some centre where a laboratory is placed, the teaching of Agricultural Chemistry at that centre might perfectly well be provided for. The assistant chemist, while engaged in his laboratory duties during part of the day, would be quite well able to give lectures on Agricultural Chemistry to students, and, from time to time, to conduct a class in practical laboratory work. The need that has been felt of late of providing a higher class of instruction for Native Forest subordinates emphasises the desirability of giving, in some such way as I have suggested, a training in Agricultural Chemistry as part of their Course.

An assistant chemist to officiate in the absence of the "scientific adviser."

A third advantage would follow such an appointment. The changes, the leave-takings, &c., necessitated by a residence in India, oblige the provision of a substitute to take the place of an absent officer. Should this be the case with the senior man, it would certainly be an advantage to have an assistant chemist who, while working under the senior man, would be able to take his place in his absence, and thus not allow his work to be at a standstill. It may be necessary, perhaps, at some future time to fill a vacancy in the higher office, and it might be found better to promote the junior man to the senior post, and utilise the knowledge of India which he has already gained, rather than to make a quite fresh appointment, and to bring over a new man who would first have to go about and learn the agricultural conditions for himself, as his predecessor had done.

The qualifications of an assistant chemist.

430. The qualifications of an assistant chemist must primarily be :—

1stly. That he be a competent Analytical Chemist.

2ndly. That he possess aptitude for teaching, a good general knowledge of science, and sufficient special knowledge of Agricultural Chemistry to enable him to impart instruction in it.

The location of a laboratory.

431. It must now be considered where the laboratory and the assistant chemist are to be located. It is naturally desirable that special work, such as is here involved, should be carried on under as favourable conditions in regard to climate and situation as is possible. But, at the same time, a laboratory should not be so isolated as to fail to be of benefit to India as a whole. As the "scientific adviser" is to be imperial, this might be a reason for his being attached to the Government of India, and for changing his *locale* when they do, so that he might be available when his advice was needed. But, though it may be desirable to have the "scientific adviser" in touch with Government, I would rather see him peripatetic in character, and have him go about the country wherever and whenever required. Besides, neither Calcutta nor Simla appear to me altogether desirable places at which to establish a laboratory, certainly not for a whole year. Calcutta is quite at one corner of India, and, in regard to climate, is not suitable all the year round, while Simla is also too far removed from the rest of India, and is not likely to form a good educational centre. I confess my own predilections for choosing, were it possible, some place which, while being agreeable on the whole, as regards climate, might be as central as possible, and hence available for the different parts and Provinces of India. Jubbulpore, for instance, is such a place, and had there been any suitable institution available there, I might have recommended its adoption as the location of the laboratory, and as the head-quarters of the " scientific adviser " and his assistant chemist. Students from all parts of India would readily be able to come to such a centre, whilst it would have further advantages in enabling the " scientific adviser" to make it a good starting point for his various journeys to different parts, whether north, south, east, or west. But I am not prepared at this stage to advise the building of any institution specially for this purpose, but, as the whole scheme is an experimental one, I think that it would be better to utilise those facilities which already exist, and to provide, as far as possible, for the development of scientific education at places where it has already obtained some foothold. Agricultural Colleges are represented principally by the institutions at Saidapet (Madras) and the College of Science at Poona (Bombay), to omit the more recently established one in the Native State of Baroda. In addition to these institutions at which instruction in Agriculture is given, there is the Forest School at Dehra (North-West Provinces). The training of Forest Students is also carried on at Poona, students coming here from Madras and Southern India generally, whilst Dehra is intended to serve the purposes of Northern India. It was in connection with the development of the Forest School at Dehra that the application first came for the appointment of an agricultural chemist for India, and, though I do not see my way to recommend the appointment of a special officer for that purpose, I certainly see a decided advantage in having a laboratory or laboratories placed where they may be utilised by Forest Students, and where their presence will include also the services of a man capable of imparting instruction in Agricultural Chemistry. At Dehra there is already a very fair laboratory, which might quite well be adapted to the new requirements; this would serve for the North of India. At Poona there is a very good laboratory also, and, besides being the centre of the agriculture of the Deccan, Poona has the further advantage of being a pleasant place during the rains. In the course of enquiries that were made when the idea of having an agricultural chemist was first suggested, it was elicited that Madras would be satisfied to send its students to Poona, and, if this plan were carried out, Poona might serve for Bombay and the whole of Southern India. After careful consideration, I think that the best plan would be to have the head-quarters and laboratory fixed for six months of the year at Dehra, and for the other six months at Poona. In this way the need of imparting instruction in Agricultural Chemistry would be met for both Northern and Southern India, and, at the same time, the work of investigation would be able to proceed under fair climatic surroundings. The Forest Students, both of Northern and Southern India, would be able to receive instruction, as well as the Agricultural Students attending the Poona College; existing laboratories would be utilised, and, altogether, this scheme recommends itself as being the best to meet existing wants.

Dehra and Poona the most suitable places.

Duties of the "scientific adviser" and assistant chemist.

432. It seems necessary now to say a word as to the duties of the "scientific adviser," and of the assistant chemist. I would lay it down, as regards the first named, that he must be given a free hand, and that no one, and no Department, exercise more than a general control over him. It is impossible to lay down rules for his guidance, and for the exact employment of his time. It will be for him to show that his appointment is justified, after due time has been given him to get into his work; but, unless confidence be placed in him to rightly employ his time and opportunities, the appointment is almost sure to end, as many have done before, in not realising what it was intended to. I hope, therefore, that if any such appointment be made, the holder will not be called upon at an early date to "justify his existence," or to give a detailed account of what he can show as the result of his appointment. As I said, it rests with him to show, at the conclusion of the term of the appointment, that its continuation is desirable, but he should not be hampered before this with having to prove that he is "earning his salary" and usefully employing his time, unless, of course, circumstances should arise which would call for his removal on personal or other unquestionable grounds.

With regard to the assistant chemist, his duties must be laid down by the senior chemist, whether it be the carrying out of laboratory work or of instruction, and for the proper discharge of these duties the senior man must be responsible.

The "scientific adviser" should not be allowed to engage in private work as well.

Should a "scientific adviser" be appointed, there is little doubt that several industries, such as those connected with indigo, tea, coffee, sugar, &c., would be desirous of availing themselves of his services, and the question arises whether he should be allowed to undertake private work and to receive emoluments from private individuals in addition to his official pay. It may, with much reason, be urged that industries such as the above contribute materially to the country's welfare, and that their prosperity is coincident with that of the cultivators and labourers employed in them, so that Government should assist in improving the different manufactures by giving the help of their scientific experts. That these industries could be improved by chemical knowledge and skill being directed to them I have no doubt, but there are, it seems to me, great objections to the utilisation of a Government agricultural adviser in technical work when there is so much to be done in a more purely agricultural direction, and when not one district or Province alone is concerned, but the whole of India. To properly take up such an investigation as, for instance, that of the improvement of indigo manufacture, the whole time of an expert scientist would be required, and for much more than a single year. Then it might be asked,—to *which* of the several industries should attention be turned first of all? My view is that each of these industries should employ its own experts, and should not look to Government for this. There is quite enough to do in each to occupy special men if selected, and what could be done in a casual way by a man engaged in general agricultural work in other parts of the country would count for but little. But there are other dangers attending the employment of an agricultural chemist in technical investigation. It is only to be expected that if a man be free to take up private work he will choose that which pays him best. More especially will this be the case if the salary attaching to the office be put at a low figure, on the ground of the chemist being able to increase his remuneration by doing outside work. I would point out moreover, that the inducement to seek private practice will tend to make a man neglect the more special work of his office, and if Government appoint an agricultural chemist with liberty to engage in other work for payment by private individuals, they must not be surprised to find their man select such work as is most remunerative to him, and engage in technical investigations rather than in the direct improvement of general agriculture. Whoever he be, a man is sure to pick and choose what he will *like* to take up, and liberty to engage in private work will, in this case, interfere with the discharge of public duties. There is not in India the desirability that occurs in England for having as agricultural chemist a man who combines with scientific skill a knowledge of the agricultural trade in feeding-stuffs, manures, &c., for, practically, no such trade exists in India. It would be far better to pay a man a high salary and let him look for nothing beyond it, than to have him, while in receipt of pay for doing agricultural work, endeavour to increase his income by engaging in outside investigations.

However,, I would by no means say that if Government thought it advisable that their chemist should take up any investigation concerning a technical industry he should not be at liberty to undertake it. But it should not be, I think, for any extra remuneration, and it should, in every case, come to him as a reference from Government, and with the request that he would, if able to do so, take up the matter in question. Any fees received for the work should go to Government. For the reasons I have given above, I do not think that any such investigation can be of a prolonged or exhaustive nature, but would have to be confined to the solution of certain definite points which it might be considered desirable to submit to the "scientific adviser" to Government.

"Scientific adviser" not to be utilised for Municipalities or as Chemical Examiner.

Similarly, I should be inclined to object to the employment of the "scientific adviser," or of the assistant chemist, by Municipalities, for their local purposes, or in the multifarious duties of the office of Chemical Examiner. Such duties are not primarily agricultural, and should be left to men specially appointed to carry them out.

The salaries of the "scientific adviser" and assistant chemist.

433. It is necessary that I should now say a few words as to the salaries to be paid to the respective officers whose appointment I suggest. Seeing that so much depends upon the standing of the men who are selected, and also upon whether a pension be or be not attached to the respective offices, it is not possible to say definitely what a proper remuneration would be.

For the senior position, either a man of established reputation and recognised scientific standing may be obtainable, or else the man to be selected must be a somewhat younger man of undoubted ability and great promise, but who has still a name to make for himself. In the former case, I do not think that, leaving out the question of pension, a lower salary than

Rs. 2,000 a month, rising to Rs. 2,500 a month, should be given. If a younger man is sought, then a salary of from Rs. 1,250 to Rs. 1,500 a month would be sufficient. These amounts depend much, of course, upon the rate of exchange taken as the basis; when I stated them in India the rupee was then at 1 *s.* 6 *d.*, but it has since fallen considerably. It will be clearer, perhaps, if I say that I think the salary of a man of established reputation should be about equivalent to 1,800 *l.* a year, rising to 2,250 *l.* at the end of the term of 7 years; or, in the case of a younger man, about 1,200 *l.* a year, rising to 1,500 *l.* It would be better, however, to do as the Agricultural Conference at Simla in 1890 recommended, and to leave the exact salary to be determined by the Secretary of State, and to be dependent upon the class of man ultimately selected.

As regards the salary of the assistant chemist, this, too, must be regulated to a certain extent by the turn which exchange takes, but a salary which is equivalent to 550 *l.* a year, rising to 700 *l.* a year, should be sufficient to attract a suitable man.

Other details of arrangement.

434. There are other matters of detail which might have to be discussed in making the above appointments. One of these is, whether it might not be well not to put these officers under the "one month rule" as regards leave; whether they should be selected from India, or be brought out from England, Germany, or elsewhere; and by whom the selection should be made. On the first point I can hardly offer an opinion; but as to the second, I am almost sure that it will be necessary to go beyond India to find suitable men, at least for the senior appointment; while on the third point I would throw out a suggestion that, if the selection be made from England, it might well be left to the Secretary of State in consultation with some agricultural body of standing, such as the Royal Agricultural Society of England.

While an assistant chemist will be readily obtainable, I am well aware that it will be no easy matter to find a man in every way suitable to fill a senior appointment such as I have sketched out. A purely scientific man might possibly be soon found who would be willing to come, and, similarly, a practical man, but the possession of the two qualifications by one man will not be so readily discovered. In the end it may be necessary to select a man of the required scientific qualifications, and who appears likely to be able to develop the practical qualifications after he has acquired some experience in India. But, unless there has been beforehand the scientific and special chemical training, it is very certain that it will not be acquired in India. Therefore, as the "scientific adviser" is to be an authority on chemico-agricultural matters, the primary requirement is that he shall have gained the special experience before coming out to India, and if he be a man of intelligence and good common sense he will he able to see what is wanted of him, and to add practical knowledge to his scientific ability.

I am conscious, too, that it may be said that in giving a man so free a hand as that which I have suggested he should have, I have left a good deal open to him, and have put but little control over him. It is quite true that this leaves much to chance. If a man be active and devoted to his work he may make his position one of much value, and render its continuation indispensable; if, on the other hand, he only studies his own comfort, he may simply make his appointment a "cosy berth" which brings him in a good salary, so long as it lasts. It is so difficult, however, to impose any system of control without at the same time destroying the practical usefulness of the appointment, that I think it is better to rely upon the individual to show that his selection and the creation of the office have alike been warranted.

The employment of other scientific men in agricultural enquiry.

435. I should be misunderstood if I were supposed to imply that all that is needed for scientific agricultural enquiry in India is an agricultural chemist and an assistant chemist. The branch of science with which I have had most to do is chemistry, and so I have spoken mainly from the standpoint of the chemist. But there is need of men expert in other branches of science too. Among these, a Botanist, an Entomologist, and an Agricultural Engineer might be mentioned. Such men may be found in India itself, and from time to time their services have been utilised; but, so far, no one has been specially attached to the Agricultural Department for the primary purpose of assisting agricultural enquiry. It would not be hard to show that, in carrying out, in the past, several lengthy enquiries, more especially that with regard to the hybridisation of cotton, the greater part of the labour might have been saved had botanical knowledge been employed in the enquiry; the same might be said of the introduction of the tea bush from China. In all matters concerning the trial of new crops or new varieties of crops, recourse should be had to the best botanical assistance available, and there are, as I have said, men in India fully qualified to give this, whereas this is not the case as regards Agricultural Chemistry. A large field is open, too, for the study of Agricultural Entomology and of the various diseases and injuries to which crops are liable. Already, at the Forest School, Dehra, Mr. Cotes, of the Indian Museum, Calcutta, has been employed in giving a course of lectures on this subject. So far, this is good; but it only covers a period of six weeks in the year, and Mr. Cotes has the general duties of his appointment at the Indian Museum to attend to as well as the more agricultural relations of the subject. I heartily approve of the employment of men of attainment in different branches of science for the furtherance of agricultural knowledge, and also for teaching purposes; but this must be done on a more extended scale than has been the case up to now, and there should be, as I have said, both a Botanist and an Entomologist attached regularly to the Agricultural Department.

A more thorough step towards attacking a great subject affecting agricultural interests was taken in the engagement of Dr. Lingard as Government Bacteriologist, and in his location at Poona (*see* paragraph 272). This appointment had only been made shortly before I left India, but of the necessity of applying the latest advances of science to the investigation of cattle diseases there can be but little doubt.

In many enquiries of an agricultural nature, questions will arise where a knowledge of engineering will be very essential. Such, for instance, are those on land reclamation, irrigation, &c. Reference has been made to the employment, in some of these enquiries, of Mr. W. J. Wilson, of the Public Works Department. It would be well that the services of an agricultural engineer should be available, not only from time to time, but regularly, for the work of the Agricultural Department.

The position of scientific men in India.

436. The consideration of the various points raised in this chapter leads me, in concluding it, to make a few remarks on the general question of the appointment of scientific men to positions in India. There ought to be no reason why India should not possess her own staff of workers in various branches of science, instead of having so often to refer questions to home *experts*. There should be authorities on scientific subjects in India just as there are in England, in Germany, and in other countries. It cannot be said that encouragement is given to the pursuit of scientific investigation in India, and if the history of the many very able men, including even a Second Wrangler at Cambridge, who have gone out to India to fill appointments, be examined, it will be found that in but few cases have they advanced by the pursuit of the particular sciences of which they went out as exponents. The fault seems to lie in the fact that men skilled in a special science, and for that reason selected for India, mostly find themselves, on arrival, drafted into the Educational Department, and forming part of a graded service. In this capacity they are obliged to move on through the different grades, taking up the respective duties of each of these, for, if they wish to keep to their own science, they must remain at the same salary as at the commencement. The outcome of this has been, that men who might have been original workers in science have had to abandon it for the duties of School Inspectors, or, despairing of further advancement in their own science, have launched out into the pursuit of Meteorology and other subjects in which they might earn distinction. I have it from men in the Educational Department who had been originally chosen for their scientific knowledge, that, when once established in a position, they find their time so taken up with teaching subjects *other than* their own science, that they have to abandon entirely the hope of doing any original work, and have not even time to keep up their knowledge of what is being done at home and abroad in advancement of their particular science. The consequence is, that they fall behind, and cannot keep their know-

Want of original workers in science.

ledge up to date. The late Mr. S. A. Hill, of Allahabad, who was a skilled chemist when he came out to India, acknowledged to me that this was the case, and that he had not been able to keep himself acquainted with the advance made in chemistry, still less to carry out any original work in the science.

Unsatisfactory nature of Chemical Examinerships.

Another instance of the way in which no encouragement is given to scientific study is seen in the system by which appointments are made to the position of Chemical Examiner. Instead of selecting for these posts men who have been carefully trained in chemistry, and more especially in analytical chemistry, the appointments are generally given to men who have had nothing more than the class instruction in chemistry and the test-tube experience of the ordinary medical student. Those who have any acquaintance with the facts know how small are the demands made upon the chemical knowledge of a medical student in order to enable him to pass his qualifying examinations, and it is simply this, or the recollection of it, which the "Chemical Examiner" in India has to rely upon when he enters upon his work. The men chosen are medical men, who, when they see the chance of adding to their income by taking a "Chemical Examinership" as well, do so, and at once find themselves, armed only with the remains of their student-days' knowledge, brought face to face with matters requiring not only special acquaintance with chemistry, but also considerable analytical skill and experience. The subjects dealt with by Chemical Examiners are of a most varied description, from poisoning cases in which human life is at stake, down to analyses of Government stores, dynamite, kerosine oil, beer, raspberry essence, disinfecting powders, and lozenges! Clever indeed must the medical man be who can do justice to such a varied selection on the strength of his medico-chemical experience! What happens is, that a man bungles on at first, doing the best he can, and, if he be a man of ability, in course of time he gets to know how to deal with the usual run of things submitted to him, and what he does not know he finds out from books. But the system is very far from being satisfactory, and it is not to be wondered at that the Reports of the Chemical Examiners are not fully credited in the Law Courts. On looking over the Reports, I find that medico-legal cases and examination of Government stores form the bulk of the work, and that the important matter of the adulteration of staple foods is one which but seldom comes forward.

Municipal chemists.

The calling of a Civil Surgeon is medicine, not chemistry, and, unless he has had a special training in chemistry, he cannot be properly qualified for holding a Chemical Examinership. Similarly imperfect and unsatisfactory are, in most cases, the examinations of samples of drinking water made on behalf of Municipalities. The investigations are incomplete; the collection of samples is too often left to messengers (*peons*) who may take them from anywhere and anyhow. Added to this, the number of samples sent, and the kind of analysis made, are determined rather by the cost than by the importance of the enquiry, and it is left to the chemist just to analyse what is sent to him, instead of carefully selecting such samples as shall be germane to the enquiry.

Central Training Institution for public scientific appointments.

I cannot but think how much better it would be if there were one Central Institution, say at Calcutta, where, with able professors and the best laboratory accommodation, men might be trained so as to qualify for filling the posts of Chemical Examiner, Municipal Chemist, Sanitary Inspector, and such like. As vacancies arose in these posts, they might be filled by men who had passed out with a qualifying certificate. In such an Institution, too, men might be trained in knowledge of agricultural as well as of general chemistry, and the requirements of India could in this way be met from India itself, and not be the subject of continual reference to England. In some such way, too, there would be an opportunity for the development of original scientific work in India.

CONCLUSIONS.

437. CONCLUSIONS.

The influence of science upon the development of agricultural knowledge has been very marked within the last half-century. Inasmuch as chemistry is the branch of science most nearly related to agriculture, its study becomes of particular importance when the improvement of agriculture is concerned. The need of having an agricultural chemist in India has been recognised alike by the Government of India and by individuals of weight in that country. There is scope for the useful employment of an agricultural chemist in carrying out scientific investigation upon agricultural problems of the day; in planning and regulating agricultural enquiry and experiments, and in examining and recording the results; in maintaining the continuity of experimental work; in acting as a "referee" or "scientific adviser" to Government on all chemico-agricultural matters; in directing the teaching of agricultural chemistry, and in aiding the spread of agricultural education by assisting in the issue of agricultural text-books.

A beginning should now be made by the appointment of an agricultural chemist to carry out the above duties. He should be a man with special acquaintance of the science and practice of agricultural chemistry, and should possess a good general knowledge of practical agriculture. The appointment of such a man should be regarded as experimental, and, accordingly, it would be sufficient to have only one man at first, who, while acting as "scientific adviser" to Government, would, nevertheless, be equally available for all the Provinces of India. He must be given time and opportunities for making himself acquainted with the conditions of Indian Agriculture, and the first appointment should not be for less than seven years. His functions should be primarily those of an investigator and adviser, and not those of a teacher. He should be provided with a well-equipped laboratory, and with an assistant chemist who shall be resident at the laboratory, do the necessary analytical work, and also teach Agricultural Chemistry. The most satisfactory plan would be to utilise the existing laboratories at Dehra and at Poona, each for six months in the year. It is not advisable that the "scientific adviser," or the assistant chemist, be allowed to engage in private work for individuals.

Further, it is very desirable that men of mark in other sciences, such as Botany, Entomology, Engineering, &c., should be attached to the Agricultural Department for purposes of enquiry and experiment.

438. RECOMMENDATIONS.

RECOMMENDATIONS.

That an Agricultural Chemist be appointed for India, to act as adviser to Government in chemico-agricultural matters, to carry out investigation, and to direct Experimental Enquiry.

That an Assistant Chemist be appointed, to act under the above officer, and to teach Agricultural Chemistry.

That to the Agricultural Department should be attached other scientific officers, such as a Botanist, an Entomologist, and an Agricultural Engineer, for the purposes of Agricultural Enquiry.

CHAPTER XVIII.

EXPERIMENTAL FARMS.

CHAPTER XVIII.

EXPERIMENTAL FARMS.

The causes that have led to the establishment of special Experimental Farms.

439. It may be said that wherever the work of agricultural improvement has been taken in hand, the establishment of an Experimental Farm has almost invariably been a part of the scheme. There are very good reasons, too, why this should be the case. Upon the carrying out of the ordinary operations of the farm at the most favourable moment depends the success of husbandry, and it has been found, over and over again, that this is hampered by the concurrent existence of work of an experimental nature, involving special care and expenditure of time. When a farmer's pocket is concerned it is hard to expect him to leave that upon which his living depends, and to attend to voluntary and unremunerative labour. When a wide stretch has to be sown at a favourable turn of the weather it is troublesome to have to delay to plan out an area, to measure out plots, to mark out paths, or to weigh out seed or manure; similarly, at harvest-time, when so much depends upon getting in a crop well, it seems to involve tedious delay in cutting and gathering plot by plot, in stacking and storing separately, in numbering, labelling, measuring, weighing, recording, and checking the produce of different small areas; so it comes about that, under the press of sowing or harvest operations, the experimental area is too often left to the last, and that which requires the most care is neglected, because there is not the time to give attention to it. The outcome of this has been that, even in England, the ordinary farmer will do little more than leave, perhaps, a bit of his field unmanured while the rest of it is manured, or he will put some particular dressing on one spot, while the remainder is treated differently, and at harvest-time he will merely judge by the eye what the result has been. But he will seldom go to the trouble of harvesting separately any definite area in order to learn precisely what its produce has been as compared with another. Accordingly, the information thus gained is known to the individual only, and even this is of an indefinite and unrecorded nature. Experimental enquiry has thus been left to those whose opportunities or means have permitted their sacrificing a certain amount of time and money, or else to agricultural bodies or Government Departments. Even where private individuals of means have undertaken experiments, there has been felt the need of guidance and supervision, of accuracy and skill such as is not generally met with in the ordinary staff of a farm, and it is now fairly admitted that, unless an experiment can be separated from the ordinary farm work, and have a man of special ability set over it, and made responsible for watching it and for accurately carrying it out, it is almost vain to expect tangible results. This has led to the confinement of experiment mainly to special places, such as Experimental Farms, or to the conduct of experiments under the guidance of men of scientific repute. This has been the case not in England alone, but in France, Germany, Italy, and other countries, so also in India. Indeed, the circumstances that have led to this result tell with more force in India than elsewhere, owing to the extreme subdivision of the land, and the absence of a cultivating landowning class. Experiment has to be carried on, therefore, as something apart from the ordinary work of a farm; it must not be hampered by the latter, and has to be judged apart from the financial expenditure incurred.

In the present chapter I intend to review the past working of Experimental Farms, and to indicate in what ways improvement in the system may be effected.

Past work of Experimental Farms in India.

440. That mistakes, and many mistakes, I might say, have been made, admits of no doubt; but that more mistakes have not been made, and that a far greater expenditure of money has not been incurred, appears to me to be still more a matter of wonder when it is considered what has been the agency at work in the past. With no scientific guidance, with no one skilled in agricultural experimental work, and with nothing but the direction of men having experience of English practical farming only, or of Civilians who have not even had this, I am only surprised that so much has been accomplished. Generally, let me say that, after what I had heard before coming out to India, and what I heard in India itself, I found Experimental Farms to be very much superior to what I had been led to believe I should find them. It has been my lot to inspect experiments in England with which many of those in India would compare very favourably. There have been, without doubt, a few men in India who have possessed a scientific spirit, and who have been actuated by a desire to work out agricultural improvement. The failing has been that the agency has been imperfect, and the continuity uncertain. Either the practical knowledge or else the scientific skill has been wanting; at all events, I do not know a case in which both have been combined in the one individual, or where there have been two individuals at work, one skilled in the one, the other in the other direction. In experimental enquiry something more is needed than that which the practical agriculturist, the theoretical scientist, still less the Indian Civilian, can supply alone. For want of a man combining scientific skill with practical knowledge, the work done at Experimental Farms has been, in great measure, a compilation of numerical results rather than of tangible conclusions, an indiscriminate mixture of good with bad, towards the sorting out of which little or no real help has been given. It is not enough to state merely what has been done, and what results have been obtained; but the results require to be criticised, digested, and presented to the public in a form which can be understood at a glance. People not directly interested will not and should not be expected to wade through all the details of an experiment, to hear of this or that failure, but they do want to get at the gist of the whole, and to have it presented to them in an assimilable form. The conclusion I have formed as to Experimental Farms is, that there has been a lot of good work done, but it is so buried among what is not good as to be almost indistinguishable therefrom. A "sorting process" is what is required in order to make the results really useful. But that Experimental Farms have been useless and extravagant institutions I am very far from admitting, or that the men who have directed them have been incapable men generally, I would not for a moment allow. Where failure has followed, it has been mainly because the conditions for success were not present. The faults are those which could be remedied by the employment of scientific and practical skill, and by having a continuous instead of a shifting agency.

The expenditure upon Experimental Farms.

441. It cannot with justice be said, I think, that, on the whole, the expenditure upon Experimental Farms has been large. Here and there instances may be pointed out where excess of zeal has prompted excessive expense, but the same might, with far more justice, be said of other experiments of Government besides Experimental Farms. When, in April 1884, an enquiry was ordered into the conduct of agricultural experiments on Model Farms, the replies received did not indicate that there had been any serious waste of money, although it was allowed that, if economy were called for, it would be necessary to distinguish between what was purely of an experimental kind and what was rather of the nature of demonstration; also that, whereas the latter might reasonably be expected to pay expenses, the former must of necessity call for direct expenditure.

Distinction between "Model Farms" and Experimental Farms.

442. My plan will now be, firstly, to indicate the general lines upon which Experimental Farms should be conducted; and, secondly, to illustrate the various points by reference to existing Experimental Farms in India.

I wish at the outset to clearly distinguish between Farms which exist for the purpose of demonstration and those which are intended for pure experiment. The former are intended to show to cultivators the result of a practice found by experiment to be successful, and, therefore, they ought to be remunerative. In this way I should have no objection to their being called "Model" Farms. But Farms at which the object is to put different methods to the test stand on a different footing altogether. The object at these latter is to find out *which* of several practices may be the best, and this of necessity involves doing a great deal that is of an unremunerative character. To make such a Farm a "paying" one is out of the question, though the experience gained from it may be highly remunerative in its subsequent application elsewhere. I intend to treat later on of Demonstration Farms, but to speak now of purely Experimental Farms.

Where Experimental Farms are needed.

443. *The Need of Experimental Stations or Farms.*—That such are needed I have already sufficiently shown. I have enumerated the reasons which prevent private individuals from carrying out experiments, and I have in a previous chapter (*see* Chap XVI., paragraph 406), mentioned several subjects which, for want of putting them to the test, still await decision. I may, therefore, take the general need as granted. It is, however, a different question *where* such Farms are needed. This has to be settled for each Province and for each district separately. To establish an Experimental Farm in a district, simply because, in the abstract, it is a good plan to have a place for trying experiments, is not a sufficient reason. The decision must be partly based upon considerations as to whether there are the means to support a Farm, and whether there be a suitable staff, but the main one should be whether there is anything definite to learn, any particular question to solve, and whether this has any relation to the agriculture of the country around. Unless these questions can be answered in the affirmative, the need for an Experimental Farm has not been made out. A *primâ facie* case must be established for the existence of such a Farm in any particular locality.

The necessary supervision.

444. *The Supervision required.*—Unless there be competent supervision there should be no Experimental Farm. This supervision should consist of, firstly, a Director, who may be the Director of the Provincial Department of Land Records and Agriculture, or his Assistant Director, where one exists; secondly, a resident Farm Superintendent or Manager, who shall see to the actual cultivation and to the carrying out of the details; thirdly, a scientific officer who shall be available for the purpose of advising and of assisting in the examination of the results obtained, and also of supplementing the work done, by carrying out any chemical analyses or investigations involved. Unless there be the above, and, of course, the necessary staff of farm labourers, an Experimental Farm should not be established.

The Bengal Agricultural Department has attempted to carry on experiments by Assistants employed in the Department. These Assistants from time to time leave their office employments in order to visit the Experimental Station for the purpose of seeing how the work is going on. I found, however, in one case, that the Farm had only been visited once in the course of the year. Such occasional supervision is of little practical value, especially when, as in the instance under notice, the resident manager was a man of very ordinary calibre, and had other estates to look after and other duties to perform. When, however, as in the case of the Cawnpore Farm, and those at Nagpur and at Bhadgaon, the resident manager is a man of ability, an occasional visit from a responsible Director is all that may be wanted, but I am very decided upon the advantage of regular inspection and control by individuals directly responsible.

The situation of a Farm.

445. *Situation of an Experimental Farm.*—An Experimental Farm ought to be so situated as to be readily accessible to those who are likely to visit it. Thus, it should not be too far distant from an important centre, and yet it should be amid agricultural surroundings. If these *desiderata* be fulfilled, the Farm may be a useful ground of instruction for the neighbourhood, and also be readily reached by those who may visit it officially, or who may supervise it, and to whom time will be a matter of importance. In this respect, with the exception of Bhadgaon and, possibly, Seebpore, existing Farms in India are well placed. Bhadgaon is, however, too far away from a railway station, besides being a difficult place to get to, owing to rivers that have to be forded; Saidapet is too near the town of Madras; Seebpore also is, perhaps, too near Calcutta and too much surrounded with dwellings, besides not being in a sufficiently agricultural district.

The kind of soil.

446. *Soil suitable for an Experimental Farm.*—Where the object is not merely to have a Farm for the conduct of scientific enquiry, but to do that which shall be for the benefit of the surrounding agriculture, the land chosen should be composed of soil which is fairly typical of that of the country around, so that the results may be applicable to as large an area of similar land as possible. If there be two or more main types of soil in a Province, this will constitute a reason for having more than one Farm in it, provided the requisite supervision be available. But to take up, on the one hand, land which is naturally so rich as to call for no improvement, or, on the other hand, land so poor or so sandy that no one would think of farming it if he could help it, is to render experiment profitless from the outset. The Saidapet Farm at Madras is, by the very nature of its soil, quite unsuited to be an Experimental Farm of benefit to the Presidency in general. It has a poor, hungry, sandy soil, and the land is little better than a great sandhill, in no way typical of any large extent of land throughout the Presidency. About other Farms I have no adverse remarks to make in this respect.

When a site, however, is to be chosen for purely scientific investigation, closer discrimination than is supplied by local considerations is required. Thus, if an experiment on the power of a certain manure be devised, the soil must be one that is neither too rich nor too poor. It must not be so rich that the influence of manures on it will not be marked, nor so poor that on this account it is not ordinarily culturable nor intrinsically worth improving. In brief, it must be a soil that responds fairly to the action of manure.

The size of an Experimental Farm.

447. *Size of an Experimental Farm.*—When an Agricultural Department or other agricultural body contemplates taking up an area of land for purposes of enquiry and experiment, the question as to the most suitable size of the area calls for careful consideration. This must be decided upon with regard to the exact purposes which the area is to serve, and the nature of the experimental work to be carried out. If experiment only is to be undertaken, and to be confined to such work as the growing of new crops and new varieties, or the effect of different manures on crops, quite a limited area will do. A Farm of 20 to 30 acres would be quite sufficient in such cases, and even a smaller one might do. Similarly, for more strictly scientific investigation there would be no need to take up more than, say, 10 acres. In the experiments at Woburn, which I have under my care on behalf of the Royal Agricultural Society of England, the main experimental field is 27½ acres in extent. Generally speaking, I would say that, for purely experimental work in crop-growing or in manuring, 25 acres is a good size for a Farm, and it would be better to confine the area to this, and to limit the expenditure similarly, rather than to take up a large farm with all the accompaniments of farm buildings, cattle, implements, &c. In short, I would not advocate taking up more land than was actually required for the contemplated experiments and for their probable extension. The larger an area is, the greater are the chances of variation in the soil, and these variations are likely to tell most injuriously when comparative experimental trials are being made, or when scientific investigation is concerned.

The objection urged against such small Farms is that they could not pay for the necessary superintendence, whilst larger ones might, and at the same time give the Superintendent enough to do. In such cases it would not be difficult to add to the purely experimental area a Demonstration Farm, or a seed-growing Farm (*see* later in this paragraph). It may, however, happen that experimental work will be of a different and more extensive nature, such as the breeding of cattle, dairy farming, silage-making, or the cultivation of crops on a practical scale, according to different existing or newly-introduced systems. In such cases an area of 25 acres would be manifestly insufficient, and the Farm would require buildings, cattle, pasturage perhaps, and it should also be able to supply the necessary crops for the maintenance of the stock; whilst, when comparative crop-growing systems are tried, the difficulties attaching to the use of small plots may be sufficient to prevent their practical adaptation to the purposes of the enquiry. The farm, though really an Experimental Farm in design, becomes then one the greater part of which is cultivated in the ordinary way, and a portion of it only is kept as a purely experimental area. An extent of 100 acres, or even more, may thus be requisite, but I do not advocate more being taken up than is really necessary, and I do not favour the establishment of such large Farms as that at Bhadgaon (Bombay), which covers 1,200 acres. A great deal of time and labour must necessarily be involved in doing the ordinary farm work apart from what the experimental area specially requires, and the risk attending the gathering-in of a crop at the proper time is too much, and the expenditure incurred too great, to prevent economical conditions from entering. It would be better not to hamper the Superintendent with more ordinary farm work than he can see to without neglecting to give due care to the experiments, and it would be wise to set apart a certain sum yearly for the purpose of experimental enquiry, and to consider it as an expense, rather than to expect a Farm Superintendent to make his farm pay by virtue of the superior cultivation of a large area exceeding the extra cost involved in conducting experiments over a portion of it. The farm at Woburn, which, by the Duke of Bedford's liberality, has been placed at the disposal of the Royal Agricultural Society of England, is 130 acres in extent, and of this about one-half is utilised for experimental crop-growing and for feeding experiments, the rest being in pasture, or else used for growing ordinary farm crops. The experiments, however, in every case occupy the first place, and everything else has to be subordinated to them. Feeding experiments on cattle and sheep are conducted every winter season: exhaustive enquiries on ensilage have been made, and yet ample room has been found on the area of 130 acres for all purposes of experiment. I have, therefore, every reason for urging that farms for similar purposes in India should not be hampered by the occupancy of a large area, and also for saying that 100 acres or a little more will be found ample for all practical requirements.

It may sometimes be thought desirable, in addition to a purely experimental area, to have a "demonstration farm" or "model farm" attached, where may be shown, on a practical farming scale, the results of what has been found successful upon the Experimental Farm. In that case the area to be taken up may well extend to, say, 50 acres. Or, with the Experimental Farm it may be desirable to include a seed-growing farm, whereon seed for distribution to cultivators may be raised. This has been done at Cawnpore, the experimental area covering 42 acres, and the seed-growing part another 12 acres, besides which an additional 50 acres is used as a fruit and vegetable garden. The combination of two such objects is, I think, very desirable for Agricultural Departments to carry out; but I would like the two to be, as at Cawnpore, quite distinct. It is impossible to state what area could be usefully employed, but, speaking broadly, 50 acres should be about sufficient in most cases at beginning, leaving it to be extended should occasion arise.

The size of an experimental field.

448. *Size of an Experimental Field.*—The size of a field should depend much upon the suitability of the situation and the nature of the soil. Thus, if 10 acres of land were required, it would be better to have two level areas of five acres each, than to have a consecutive stretch of 10 acres on land of uneven character. Similarly, if the soil varied greatly in character, or if on the same area were parts typical of two different classes of soil, two blocks in different parts would afford more information than a single one.

Conditions of experimental field.

449. *Conditions relating to an Experimental Field.*—The experimental field itself must be as level and uniform in character as possible; one part must not be on high ground, another on low ground, otherwise water may lodge on the lower level, or the surface soil from the upper may be washed down to the lower level; the soil must not be deep in one place and shallow in another, but fairly uniform throughout; similarly, the soil must be of the same quality, as nearly as can be judged, all over the area; trial diggings should be taken over the field, in order to see that there are not great apparent divergencies in these respects; the plots themselves should be removed from the influence of trees, hedges, or shade, which may affect them unequally or adversely. The previous history of an experimental field should be ascertained, if possible, in order to see that it has all been treated much alike. I much doubt whether a single Experimental Station in India has been started with any consideration as to what the previous cropping, or the method of cultivation pursued, has been. The best plan, on taking up a new area, is to grow the same crop over the whole of it for a season previous to commencing the experiment proper. By reaping the first year's crop over different parts of the field and weighing it, it can be ascertained in the most practical way whether the field be uniform or not. If wide discrepancies appear, then it is quite sufficient evidence that some part or else the whole of the field is unsuitable for experimental purposes. I am quite certain that many of the seemingly contradictory and peculiar results obtained at Experimental Farms arise from neglect of a precaution of this kind, and that time, labour, and expense might be saved in the end by the sacrifice of one year at the commencement, in order to ensure that the area chosen be a suitable one in the matter of being equal in crop-producing power.

Plan of experiment.

450. *Plan of Experiment.*—A suitable site, an uniform field, and efficient supervision being provided, the plan of experiment may next be drawn up. It is greatly from want of having a definite plan and a definite object in view that experimental work in India has failed. In the majority of cases (and I would mention the Dumraon and Seebpore Farms as examples, though the same might be said, more or less truly, of the others also) the leading idea, when an area has been found available, has been to cover it with as many experiments as it will hold, regardless of the possible developments that may take place after the experiment has once been started. This position, I know, has, to a great measure, been forced upon those who are in charge of such Farms, and they have been expected to evolve as many results as possible in the shortest time, and the abundance of experiments in progress has been the criterion of activity rather than the intrinsic worth and accurate carrying out of those that have been undertaken. There is a common impression that an experiment can be carried out upon the first subject which suggests itself, and that the more varied the forms be in which it is presented, and the more numerous the plots which compose it, the more valuable and exhaustive the enquiry must be. This may be, and generally is, an entire mistake.

Two main divisions of experimental enquiry.

451. The first thing, in planning out an experiment, is to have a definite object in view, and then to arrange the details so that they may best conduce to the attainment of the object.

Now, experimental enquiry may be of two kinds.

Scientific investigation.

Firstly, it may be more specially scientific in character, such as the finding out of fresh scientific truths, or the testing of scientific theories. These experiments can only be carried out under the immediate supervision and care of a man of scientific attainments, such as the "scientific adviser" spoken of in the last chapter. The arrangement of them, and the entire control, must be left absolutely to him, and they cannot be made distinctly popular, or be always set out in such a way as to clearly demonstrate to everyone the line of enquiry pursued. Briefly, they need such explanation for their right understanding as only a specialist can give. The area occupied by investigations of this kind will, however, be but a limited one, and they may frequently be even of a laboratory character. Of this nature are, for example, experiments on the nutrition of plants, the assimilation of different soil constituents or of atmospheric gases by plants, the exhaustion produced by continuous cropping, or the effect of extreme applications of stimulating salts. These find their counterpart in England in the most distinctly scientific experiments carried out at Rothamsted by Sir John Lawes and Dr. Gilbert, and to a lesser extent in those at Woburn.

Practical experiment.

Secondly, experiment may be of a more practical kind, such as the testing of the value of different processes already in use; the economical effect of various manurial ingredients upon particular crops; the collection of information regarding the outturn of crops; the growth of new crops and new varieties; the trial of new implements. For these, considerably larger areas will be required than for the more scientific investigations.

Experiments must have a bearing upon actual agricultural practice.

452. Whichever be the kind of experiment, in each alike a definite plan must be set forth. For the existence of this, in scientific investigation, the expert himself may be trusted, and it may not be possible, as noted previously, to indicate this to the comprehension of everyone. But in the practical experiments the object and the plan should both be set out clearly and unmistakably. I may be allowed here to give a few hints, illustrating them by what I noticed at Experimental Farms in India.

The first requirement is, that every experiment should have a distinctly practical bearing; in other words, it should consist of the trial of something which, should success in the experimental stage attend it, will be capable of practical application to the farming of the country, and effect an improvement in it. There must be some *primâ facie* ground for believing that what is tried by the experimenter may be carried out by the cultivating *raiyat.* Thus, a manure might be tried which the *raiyat* is not able to get, either because it is beyond his power to purchase, or because it is not obtainable in sufficient quantity; an implement might be experimented upon, which would always be beyond the *raiyat's* purchasing power; a crop might be grown which would be of no use to him, or which his prejudice would prevent him from touching. In all such cases the experiment could do but a limited good, and often no good at all. Yet this kind of experiment has been carried out again and again on Government Farms, and the fact accounts, in no small measure, for a good deal of the odium which Experimental Farms have incurred in the past.

Manures employed should be those in common use.

Expensive machinery is out of place.

So with certain crops.

At the Cawnpore Farm I found that the best result in wheat-growing, and also in potato-culture, had been derived from the use of wool waste. But, on enquiring where it could be obtained, I heard that it came from a manufactory near by, and that the Farm took the whole of the waste. There are but few such factories in India, and the amount of wool waste produced is insignificant. What good can it do the *raiyat*, therefore, to know that, in order to get the best crop, he must use what is not even an obtainable article? In another experiment I found that muriate (chloride) of ammonia was used, a material far beyond the power of the *raiyat* to get, whatever might be the benefit to be derived from it; besides this, the muriate is one of the dearest forms in which ammonia can be purchased. Also, I saw plots on which the refuse water from indigo manufacture, called *seet* water (*see* paragraph 348), was used. But it is only here and there that *seet* water can be procured. Again, for an experiment to have been properly conducted, the plot for comparison with the one treated with *seet* water should have had supplied to it a corresponding volume of *ordinary* water in order to make the trial a fair one, but I could not gather that this had been done. The manures to be tried on Experimental Farms should be those which are within the power of the *raiyat* to obtain, and which are in general use throughout the country, or else those of which there is some likelihood that use will be made in the future. Expensive chemical manures imported from England can at present have no place in the *raiyat's* farming system, and, therefore, they should not be included in practical experiments. I found at the Cawnpore Farm a thrashing machine, costing, perhaps, 200 *l.*, and another at the Bhadgaon Farm, while Madras Reports speak of an English seed-drill at the Saidapet Farm which cost some 70 *l.* Such implements are, on the face of it, beyond the reach of cultivators, and it should be only under very special circumstances, such as the preferment of a request from Government that they should be tried, which should induce their purchase for any Experimental Farm. It may be desirable, perhaps, to know whether a threshing machine would pay to use in the event of wheat being sold in bulk, or of its being required clean, or else when coming off large Estates. But these are exceptional cases, and should not form a part of the ordinary duties of an Experimental Farm, the primary object at which is to attempt what may improve the *raiyat's* agriculture. At the Poona Farm I saw arrowroot being grown, but, though it flourished well, there was the objection that there was no sale for the produce. It may be said, of course, that, though a crop or even an implement may not be immediately available, a use for it may be found later on; such a case is that of the potato, a crop first despised, but now largely grown. But, though information may sometimes be gained which may be useful afterwards, I would urge that, in the main, the principle I have enunciated should be kept in view.

The issues of an experiment should be simple.

453. Experiments should be as simple as possible; they should be self-evident, and ought only to need the minimum of explanation.

It is not a good experiment which has a great many issues resulting from it; an experiment is not enhanced in value by reason of the many items that contribute to it, or of the many plots which are taken up in its demonstration. There should be clear and definite issues involved, and one only rather than a number. Each plot of an experiment should be set to answer some definite question, and each should be essential to the enquiry, and not be merely one of a number making up the series. If it be desired to bring out the influence of any particular manurial ingredient or chemical element, the presence or absence of that ingredient or element should be the *one varying factor* among conditions otherwise alike.

In manurial experiments the principle should be aimed at.

454. When manurial experiments are tried, it is not enough to mark out a number of plots upon which the same crop is grown, and to apply the manures indiscriminately, without relation to one another, the soil or the crop. Something more ought to be sought for than to know that this particular manure is better than that one; the *principles* of manuring ought to be aimed at, and the endeavour should be made to find out why it is, or what it is in one that makes it superior to another. The principle being involved, the application of it to other materials embodying that principle, or to altogether new ones, may constitute a further, and possibly advantageous, advance in practical knowledge. But if, as I noticed at Dumraon, at Nagpur, and elsewhere, a number of manures be chosen without regard to their composition or nature, such as bones, lime, superphosphate, saltpetre, &c., only empirical knowledge as to these particular materials will be obtained, and not that of the principles in accordance with which they and others like them may prove useful. Comparisons should be made upon some clear basis; thus, farmyard manure, green-manuring, and night-soil have a certain affinity, in that they all are what one may term "organic manures"; but bones and nitrate of soda have no affinity, nor yet has lime to either of the others. It may be well to try whether phosphatic manures or soluble nitrogenous salts are required for a crop, and then bones might be tried against nitrate of soda, but bones would be hardly sufficient in themselves to test the question, and other forms of phosphatic manures should be tried as well. A further question may arise, viz., in what form is phosphoric acid best applied, or in what form should nitrogen be used? Each of these calls for an experiment by itself, which, when solved, may be turned to the elucidation of the original enquiry.

Comparisons should be made on a clear basis.

An area once manured is for a time afterwards rendered useless.

455. The setting-out of the plan of an experiment, therefore, is not such a simple matter, and needs more knowledge and experience than the amateur agriculturist is able to command. Nor must it be forgotten that when an area is once covered by a manurial experiment it is most certainly spoiled for future experiments for some little time to come, inasmuch as the manures are not dissipated at once, but their effect will, as a rule, be seen on subsequent crops as well. I have constantly found this principle ignored, and experiments have been started afresh on ground which has been variously manured during the progress of a previous trial. The essence of a comparative experiment is, that all the plots should start fair and level. Yet I find that at the Nagpur Farm a complete manurial series was conducted for several years in succession with manures thoroughly divergent in character, such as saltpetre, bone-dust, cattle-dung, green-manuring, &c., and then the series was exactly reversed, and manures were put on where others, quite different in nature, had been previously applied, the land meantime having had no opportunity of resuming its equality of producing power. Satisfactory results in such a case could not be expected.

Previous treatment and relation to soil and crop should be considered.

456. At the Poona Farm an experiment was being tried with *juár* (millet), but over one-half of the area sugar-cane had been the crop, and over the other half, gram (a pulse). Such previous uneven treatment of the land is quite enough to interfere with the success of an experiment. Manures should be chosen with reference to the soil and the crops, and, in drawing conclusions, it should be borne in mind what the conditions are. Thus, a soil rich in vegetable matter would not be the one on which organic manures like cattle-dung or green-manuring might be expected to yield such a high return as on soils less well-supplied. Nor would soluble nitrogenous manures be likely to benefit pulse crops as much as they would cereals. Hence, conclusions, in order to be sound, must not be laid down without reference to the particular conditions that prevail at any one spot.

The advantage of a continuous manurial series with one crop.

457. I am in favour of having what I saw at the Experimental Farms at Cawnpore and at Nagpur, viz., a continuous series of manurial experiments on some one or more staple crops, such as wheat, cotton, sugar-cane, &c., the same crop being grown and the same manures being put on year after year. It may be said that this would not occur in practice, as a rule, but it is the way in which the best information is brought out as to the requirements of the particular crop, and also as to the effect of the different manures used; the varying influence of seasons is eliminated, and accidental occurrences are corrected by the sequence of several years. Yet this plan must be intelligently carried out, and not in the way that it was done at the Experimental Farm of the Nadiad Agricultural Association. Mr. Ozanne had, at the beginning, laid out the line of experiment, intending the Association to try it upon the general rotation adopted in the district, but, the crops having been once sown and the manuring put on, both were continued year after year afresh, just because the "Director *sahib*" had started it in this way. On coming there again, some years later, Mr. Ozanne found the appearance of the field just as he had left it.

Feeding experiments.

458. Occasionally, feeding experiments have been undertaken. For example, at Saidapet Farm (Madras) I saw a pen of four sheep being fed on earth-nut cake with other foods, and four without any cake. Again, at Poona it has been attempted to gauge the relative milk-yielding qualities of cows of different breeds by taking single specimens of each. To anyone who has had experience of experiments with cattle or sheep it will be readily apparent that to attempt to draw conclusions from four sheep or from a single cow is almost worse than useless, in fact it may often be totally misleading. The "personal equation" with farm animals is so great that, unless a sufficient number be experimented on, no proper conclusions can be drawn. Animals forming a part of an experiment must be of the same breed, the same age, and the same up-bringing, as nearly as possible. In the Woburn sheep experiments the number of sheep forming each pen is from 20 to 30, and I should not like to take a smaller number. When cows are concerned, there come in further considerations as to the date of calving, the time of year, and other fluctuating circumstances which render absolute experiments with milking-cows a very difficult and intricate matter. In the Rothamsted experiments on the value of silage as against roots for milking-cows, Sir John Lawes and Dr. Gilbert were not satisfied with less than 30 cows in each set. Of course these last experiments were for absolute accuracy, and I would not say that useful general information could not be obtained with a considerably smaller number of animals; yet it is quite hopeless to attempt it with half-a-dozen sheep, or with two or three cows.

Illustrations of experiments to be tried.

459. I am strongly in favour, therefore, of having practical experiments in India of as simple a nature as possible, and involving only clear issues. There are many experiments which are of this nature, and a plot cultivated or manured in one way placed side by side with another cultivated or manured differently may afford more information than any elaborate series offering several and often confused issues. The greatest good will, I believe, result from exhibiting side by side some native practice and another by which it is proposed to replace it. Of this kind are the following: deep ploughing *versus* shallow ploughing; thin seeding *versus* thick seeding; different depths of putting in the seed; different times of planting; different modes of cultivation; irrigation by means of heavy or light waterings; green-manuring with various kinds of crops, and so on.

Native and introduced implements must be placed side by side.

Similarly, in the case of trials of implements. It is not enough to exhibit a new implement and to show what it can do by itself. It needs to be put side by side with a native one, and, indeed, the cultivator, before he is persuaded of its value, must work the two himself side by side on his own holding, otherwise he will go away from the Experimental Farm or the Agricultural Show and content himself with merely saying what a good implement the new one is, but without the least intention of replacing his own by it.

The advantage of simultaneous experiment in different parts.

460. One great advantage of having all experimental work under the general survey of a "scientific adviser" is that, by this means the same experiment may be concurrently tried over different parts of India. In this way general truths may be obtained for the whole country instead of for one particular spot only. A uniform result would be of far more lasting and wide-reaching benefit than more numerous ones which might be the outcome of the peculiar circumstances of special districts. I would much rather see a joint conclusion of this kind arrived at as the result of experimental work on Farms than the many and often conflicting conclusions which are now drawn.

The size of experimental plots.

461. A few words may be said in regard to the plots themselves and their arrangement in an experiment. First, as to their size. In this respect I have not much fault to find with what I saw in India. As a general rule, I might put it that the maximum size of a plot should be one acre, the minimum size one-tenth of an acre. For merely trying new crops or new varieties of crops, considerably smaller plots might be used, but where there is anything of a strictly comparative nature to be tested, I do not think that it is thoroughly satisfactory to take less than one-tenth of an acre. I am well aware that much has been said as to the convenience of quite small plots, and of "pot culture" as against field trials, but "pot culture" requires far more constant and special watching than field plots, and small plots are liable to many more extraneous and accidental disturbances than larger ones. The multiplication of the crop of a small plot into the acreage return means also the multiplication over and over of every slight error, and this may become a big one when taken on the acre. On a small plot, I contend, the crop is not a fair index of the acreage yield, for along the edges of a plot it will always stand higher than elsewhere, having a wider area from which to draw nourishment; on the other hand, injury to a single plant either by insect or vermin pest or by disease will affect the produce of a small plot, whereas on a good-sized one this will be immaterial. I well remember being taken over an Experimental Station in England which was conducted by a strong advocate of the system of small plots. Noticing a luxuriant deep-green spot on a patch of wheat which was meant to exhibit the effect of withholding nitrogen from it, I enquired how this green spot came, and I was told that the horse used in the ploughing had, unluckily, chosen this particular spot for halting a moment and letting some highly-nitrogenous manure fall upon the plot. The plot was only one thousandth of an acre in extent, and it is not likely that the horse would have stopped similarly one thousand times while ploughing the entire acre, nor would a hare or rabbit, perhaps, nibble off from an acre just one thousand times as much as it had done from a small plot. Besides this, although small plots and "pot culture" may serve useful purposes in careful hands, I do not consider the results to be more than *indications* of what is likely to occur on the large scale, and, until confirmed by field experiments under the natural conditions which present themselves in practical agriculture, they do not carry conviction with them. It is not possible in "pot culture" to imitate the natural conditions, nor the influences of temperature, atmosphere, water, and soil which are at work in the open field.

The disadvantages of small plots.

Duplication of experimental plots.

462. The system of having duplicate plots in an experiment is a very wise one. By this means an anomalous result may often be checked, and a satisfactory one be confirmed beyond doubt. The provision of duplicate *unmanured* plots is even more important, for, by having these, one in one part of the experimental area, and one in another part, it is at once established whether the two unmanured plots substantially agree; in other words, whether the field is of even producing capacity, and, in this respect, suitable for experiment. A great deal of trouble, and also money, could, I am sure, be saved in experimental work, and far more satisfactory and conclusive, though less comprehensive, results be arrived at, were this system of duplicate plots, more especially of unmanured or "standard of reference" plots, more extensively used.

Space to be left for extension of experiments.

463. Next, it is a wise provision not to take up, at the outset, the *whole* of the space allotted to an experiment. As the trial proceeds, fresh issues may present themselves, which may render it desirable to add other plots to the series, or one part of the area may not be as uniform as another, and repetition of a part of the scheme may be desirable. Space for extension of the experiment in the future should, accordingly, be reserved.

The separation of experimental plots.

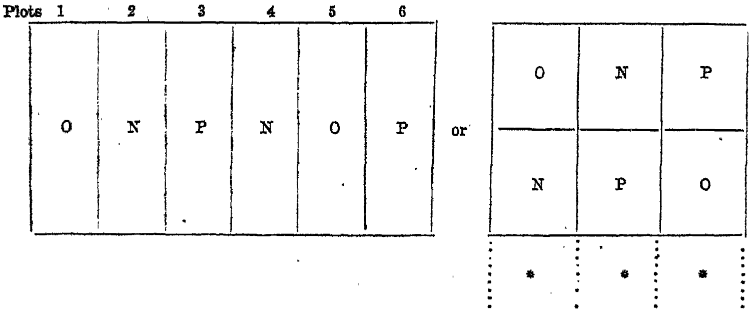
464. Further, it is a good plan to have the experimental plots carefully marked out by pegs, and divided by small paths from one another, while the area covered by one experiment should be separated by a broader interval from an adjoining one. This provides for the better supervision and observation of the crop, and, by adopting it, differences and inequalities can more easily be noticed.

A specimen plan of experiment.

465. I might here set out a simple plan of experiment which is capable of further extension if needed, but which, even as it stands, is quite comprehensive enough to yield useful results if properly carried out.

Suppose the plots marked N to be those on which an existing *native* system of cultivation or ordinary method of manuring is carried out, and the plots marked P to be those on which a *proposed* new system is to be tried, while those marked O represent the unmanured plots or *blank* plots which test the soil's natural produce.

We might have the following arrangements of the area, according to the space at disposal, or the position of the field :—



O Blank experiment or unmanured plot.
N Native system or present manuring.
P Proposed system or proposed manuring.

* Space for possible extension of experiment.

In either of these arrangements the carrying out of experiment *in duplicate* would ensure greater accuracy.

An actual experiment and the explanation of its objects.

466. To give an instance of what I should consider a good experiment on the manurial treatment of a crop, I quote the following from one of the Field Experiments of the Bath and West of England Agricultural Society, conducted in 1889 upon the barley crop.

A	B	C	D	E	F
1¼ cwt. Nitrate of Soda. 2 cwt. Mineral Superphosphate. ¾ cwt. Muriate of Potash.	1 cwt. Sulphate of Ammonia. 2 cwt. Mineral Superphosphate. ¾ cwt. Muriate of Potash.	No Manure.	1¼ cwt. Nitrate of Soda. 2 cwt. Mineral Superphosphate. 3 cwt. Common Salt.	1¼ cwt. Nitrate of Soda. 2 cwt. Mineral Superphosphate.	No Manure.

Manures per acre.

Upon examining the above scheme it will be seen that each plot is set to answer some definite question, thus :—

1. The duplicate unmanured plots C and F give the natural unmanured produce of the soil; they tell whether the two parts of the field are of equal fertility, and hence whether the area is a suitable one for experimenting on. Also, they give the basis for telling to what extent any of the manurial applications have been of benefit.
2. The plots A and B tell whether nitrogen in the form of nitrate of soda, or of its equivalent in sulphate of ammonia, is the better; as the other manures comprising the mixture remain the same in each case, any difference would be traceable to one or other of the nitrogen-containing manures.
3. The plots A and E, being alike in all respects except in the presence of potash salts in plot A, answer the question as to whether the addition of potash is beneficial or not.
4. The plots D and E, being alike in all respects except in the presence of common salt in plot D, enable one to tell whether it is advisable to add salt to the manurial mixture.
5. The plots A and D answer the question as to whether the dearer muriate of potash is better than the cheaper muriate of soda (common salt).

The above experiment was accordingly designed to bring out, with comparatively few plots, some very definite issues as to one particular point, viz., the manuring of the barley crop. Further, it was tried simultaneously upon no less than 19 farms in different parts of England, and on land where in each case the same crop (wheat) had preceded the barley. Hence the results acquired special importance, and the experiment was an eminently satisfactory one.

This concludes the consideration of the *Plan of Experiment* (commenced in paragraph 450).

Recording of details.

467. *Recording of details.*—During the progress of an experiment, details of what takes place, either in the ordinary course of cultivation, or else abnormally, should be recorded. Thus, there should be notes made of the time at which the different field operations are carried out, the preparation of the land, the time of manuring, of sowing, of watering, of ripening, and of harvest and threshing; also, special occurrences, such as those of heavy rainfall, continued drought, frost, blight, failure of plant, injury to plot, or other unusual feature, should be recorded. These need not be made use of in a Report, else it may be overburdened with details, but they will certainly be very useful when the results obtained are compared, and will aid in explaining the anomalies which so frequently present themselves in an experiment. It may, for instance, be established in this way that one part of an experimental plot is always of higher natural productive power than another, or that one part, by its situation or exposure, is more liable to damage of crop than another; all such irregularities should be taken into account, and they can only be found out by continuous watching of the experiment during its progress.

The cost of cultivation.

In the generality of experiments which would be carried on at Farms in India it is desirable that, so far as is possible, a comparative record of cost of cultivation should be preserved, and also that, where manurial experiments are tried, the cost of the different manures and their application should be noted and clearly indicated. It is well that each plot of an experiment should be distinctly labelled, the label bearing a concise description, both in English and in the vernacular, of the treatment of the plot and the experiment of which it forms a part. This should contain a statement of the cost of the manure, when any has been applied. The importance of being able to see at a glance what is intended to be conveyed by an experiment is obvious. In more distinctly scientific experiments the factor of cost does not enter, as the object is to test a theory or ascertain a truth, whatever the cost and trouble involved may be. But in experiments that are to bear directly upon actual practice the question of relative cost must not be excluded, and it becomes in the end the standard of appeal by which success is to be gauged. At the same time, the very circumstances of an Experimental Farm, the necessity of using hired labour, the extra cost of superintendence, the smallness of the plots, the additional expenses involved in separate cultivation, harvesting, threshing, &c., prevent the statements of cost from being more than relative in character, and they do not represent actual costs.

Statement of results.

468. *Recording of results.*—The recording of results should be, as far as possible, upon one uniform plan. On looking over the Reports of Experimental Farms I find that in the statement of harvest returns the results are sometimes given in terms of increase or decrease per plot, as compared with the standard, or unmanured, produce, sometimes in reference to difference per acre, and sometimes in terms of "percentage of difference." It would be much better if an uniform system were maintained throughout. When the Report is written in English, the most convenient standard of reference is the acre, and the weights should be taken in tons, cwts. qrs. and lbs., or else in bushels. There is no need to overburden a Report by stating the produce "per plot." What a particular plot produces is of no interest; it all depends upon what the size of the plot may happen to be. If, however, the Reports be written in the vernacular, it is difficult to say which is the best plan to adopt, whether the local land measure and local weights, or whether "standard" ones, should be taken. The different values attached to the *bigha* (land measure) and the *maund* (weight standard) in the various Provinces make the interpretation of results difficult. The Imperial *maund* of $82\frac{2}{7}$ lb. and the English *acre* would probably be the best understood "standards." The most natural plan at first sight would seem to be to use the local equivalents, but, seeing that the experiments are intended also for comparison with other parts, the best way would be to adopt, both in the English and the vernacular Reports, a double system of classification, the one local, the other general, and to put them side by side, with the necessary explanatory remarks as to the terms used.

In every case I think that increase or decrease should be stated in terms of "increase over standard plot," or "increase over unmanured plot," calculated upon (*a*) the acre, (*b*) the local *bigha*.

Not desirable to give results in money equivalents.

In some Reports I have noticed that the attempt has been made to translate the results obtained into a *money* figure. It may be naturally argued that, since the money gain is the final test, an experiment ought to show what this is. The same feeling has been expressed with regard to English experiments, but I may say that I have always upheld the system which I consider much better, viz., to state the *actual results* obtained, and to leave people to apply them to their individual and varying circumstances. This has now, so far as England is concerned, been recognised as the best plan to follow, and I certainly advocate it for Experimental Farms in India. The weights obtained at harvest are *actual* ones, and always remain good for purposes of reference or comparison; they are *facts* obtained. The money values that one may assign to the items of produce are, however, *hypothetical*, and depend entirely upon the particular conditions that may prevail at the time they are made, and these conditions are liable to constant fluctuation. Thus, what may be profitable under one set of circumstances may be converted into a loss under different surroundings; and so, while no one can dispute the actual weights obtained, the translation of them into money figures may involve erroneous assumptions, or, at least, assumptions which have but limited and local application. A single incident will elucidate this; it makes a considerable difference in farming whether the price to be put on produce is the *selling price in the market* or the price of it *consumed on the farm*; often it may happen that there is no market for a certain article in one district, though there may be in another; straw or green fodder may, near a town, be highly profitable to sell, while, at a distance from a town they may have only their *consuming* values. It is decidedly better, therefore, to state the results of an experiment as they are obtained, and then to leave each person to apply them to his individual case, and to translate them into the money figures that would hold good in his own district.

Examination and publication of results.

469. *Examination and Publication of Results.*—The absence of a careful and critical examination of the results obtained has been one of the worst features of experimental work in India, and it is largely owing to this fact that it is so difficult, when taking up any Farm Report, to do what may be called "make head or tail out of it." Something more is needed than merely to put down the results obtained, and to leave them in a tangled, unassorted, and often self-contradictory form. Each result should be studied by itself first, and then in the light of other results, and it should only be allowed to be put on record after it has stood the test of critical examination. It has been said, and rightly said, that failures, as well as successes, should be recorded, and that there is often much to be learnt from failures. With this I fully agree, and I think it is quite right that failures should be recorded, and the reasons, if known, should be set out. But, when an experiment is thoroughly bad in design, or when it has been damaged during progress, or when results obtained are evidently unsatisfactory or contradictory, I cannot see the force of putting out the experiment in detail, and of trying to draw conclusions from it, still less of burdening a Report with it, and of burying a good experiment amidst the records of bad ones. If desired, these may be put in a separate section, but the main Report should, I think, consist purely of the record of those experiments which have passed a critical examination, and which constitute a distinct advance in agricultural knowledge. The examination of the results, it is clear, demands the employment of someone particularly qualified for the work; such a man, for instance, as the proposed "scientific adviser" would be. As I said in the last chapter, this would, I consider, constitute one of his chief duties. When results are obtained at any Experimental Farm they should be sent to the "scientific adviser" for his perusal and examination, and it should be for him to say which experiments are good and satisfactory, and to be placed on record, and which ones should first be tried over again, or should be omitted altogether. Of course, it would be quite understood that the "scientific adviser" would have no positive *veto* on the publication of what he did not approve of; all he could do would be to offer his opinion, and it would still be quite open to Provincial Governments to print what they liked. At the same time, however, as the Imperial Government would, in all probability, issue a record of experimental work for the whole of India, it is only reasonable to suppose that they would only take cognisance of what the "scientific adviser" deemed worthy of publication. The issue of a general Report of this kind, not for one Province alone, but to combine the results of work in the several Provinces, would be very useful.

Advantage of having a "scientific adviser" to examine results.

I may be allowed to give, from my own experience, an instance of the useful supervision which such a "scientific adviser" could exercise in the elimination of bad or imperfect results from good ones. When asked to go over the Report of one of the Experimental Farms in India (the Farm being, I might add, certainly one of the best), I found drawn up at the end of the Report the results obtained for each experiment carried out. This had been done in the form recommended, after general conference with Agricultural Directors, by the Revenue and Agricultural Department in their Circular, No. 143A, 28th December 1885. In the column entitled "Comparative Record of Experiments" were given no less than 35 different results for this one Farm. After going carefully over these, and after eliminating the ones which I considered unsatisfactory, the number of results was reduced to 11, and these 11 results were all that I should have advised being placed on record. It would be far better to have, and far easier to follow, 11 good results that would bear criticism, than 35 results, many of which would not.

Dissemination of results.

470. *Dissemination of Results.*—Upon the wide dissemination, in a clear and intelligible form, of the results of experiment depends much of their value and also popularity. There should not be too many Reports, and I should say that an annual one for each Farm or set of Farms is all that is needed. There is no call to have a Report for each season's crops.

It is not possible to preserve complete uniformity in the returns, nor to lay down any precise plan for setting out the results. One experiment may require to be stated in one way, another in a different way. The most that can be done is to make these as alike as circumstances will permit, and to have one system of units adopted in one column at least, of the returns, so that they may be comparable at a glance, and not have to be calculated on to a common basis. Thus, to give results in one case in weight per acre, in another in weight per local *bigha*, at one time in *maunds* of 80 lbs., and in another in *maunds* of 40 lbs. [as in Gujarát (Bombay], or in *maunds* of 28 lbs. (as in Coorg), is sure to cause confusion; and, therefore, the adoption in one column of a statement in terms of acres, and of tons, cwts. qrs. lbs., or else of bushels, is necessary. This should be done in the English Report.

Reports in the vernacular also.

But I think it is very desirable that the Reports, or at least an abridged version of them, should be published in the vernacular also, and be disseminated in this form. It is mainly by such means that the work done at Experimental Farms can be popularised, and its results be brought to the knowledge of the cultivators. I read that already a considerable number of the neighbouring cultivators visit the Cawnpore Farm; but if there were a Report of the experiments in the vernacular, together with a plan of the the Farm, the latter would become an object of far more interest.

Periodical visits to Experimental Farms

This leads me to observe that it would be a good plan to organise periodical visits to Experimental Farms, when, under the guidance of the Superintendent or Manager visitors might be taken round to study the experiments, and any necessary explanations might be given on the spot.

The publication and dissemination of the results of experiments should be undertaken by Government, and not be a direct charge upon the Farms.

The necessity of time and patience in experimental work.

471. *Need of Time and Patience.*—If, in any agricultural work, time and patience are required, it is in that of experimental enquiry. A result is really not a good one until it has been repeated, and sometimes often repeated, with the same result. It is only by repetition that errors can be avoided, and accidental circumstances be eliminated. A difference of season may easily cause a difference of crop, or even of result; but by repeating the experiment the varying influence of season will be checked. I regard it as far more useful to get one sound result, the outcome of trial in different years, and under varied conditions, than to get fifty or even a hundred results which subsequent experiment might disprove. I sincerely trust that, if a fresh impetus be given to experimental work by its re-establishment under a system such as I have proposed, Provincial and Imperial Departments of Agriculture will recognise that time and patience must be given, and that they should be content to wait for solid results, rather than that they should press those in charge to give returns which, unsupported, have but little value.

The financial test is not to be applied to Experimental Farms.

472. *Financial Test not criterion of success.*—I have already drawn (*see* paragraph 442) a clear distinction between Farms for *experimental* and those for *demonstration* purposes, and in the foregoing paragraphs I have mentioned, in passing, several circumstances which constitute differences between farms under ordinary cultivation and those devoted purely to experiment. The financial result of the working of an Experimental Farm should not be taken as the criterion of its success. As I pointed out, when different systems are put to a test, there may be many which prove unsuccessful, and perhaps only one a success, or else all alike may be found to be inferior to an existing practice. This is not money thrown away, though it is money spent; knowledge is gained in this way, and it may be the means of saving much larger expense in the future. But there are other matters, special to an Experimental Farm, which involve expenditure not ordinarily incurred. When areas are small, as experimental plots generally are, and when these are marked out and separated from one another by paths, &c., their cultivation is of necessity much more expensive, and the ground is not so fully covered as if a whole stretch were cultivated alike. The application of manures, or of watering, is more difficult, and involves more care and time; when harvest comes, crops have to be kept separate on the different plots, and to be reaped, threshed, and weighed separately. The entire economy of labour on the large scale is lost thereby. But it is in the matter of the employment of labour that a heavy burden rests upon Experimental Farms, and one which constitutes a great difference between the conditions of the Farm and those of the *raiyat's* small holding. The *raiyat* employs on his holding his own labour and that of his family, rarely using any hired labour; but on an Experimental Farm all must be hired labour, and it is often very hard to procure this, nor is the labour always of the best, for a man does not work with the zeal that attaches to his own cultivation.

I have looked into the expenditure of Experimental Farms in India, and although there have been instances, especially in the case of Saidapet (Madras), of excessive expense incurred, I cannot say that I think that, on the whole, unreasonable sums have been spent on these Farms. The Bhadgaon (Bombay) Farm, comprising 1,200 acres, cost over and above receipts, in 1888, Rs. 990 only, and in 1889, Rs. 743 only, exclusive of the superintendent's salary of Rs. 3,000; the out-of-pocket expenditure on the Nagpur (Central Provinces) Farm of 90 acres, was, in 1888-89, Rs. 3,744. These amounts do not read as large ones when compared with the 600 *l.* to 700 *l.* a year which the Duke of Bedford gives for the support of the Woburn Experimental Farm of the Royal Agricultural Society of England, or the very much larger sum (probably about 3,000 *l.*) annually expended by Sir John Lawes upon the world-known Rothamsted experiments. In the United States of America there are 54 Experimental Stations, all of which are subsidised by the State, a sum of 3,000 *l.* a year being paid to each.

The kind of experiments suited to Experimental Farms.

473. *Suitability of present Experiments.*—I have no fault to find, as a rule, with the kind of experiments which have been conducted on Experimental Farms, and I would not suggest, therefore, any divergence from, or great extension of, what has been the aim in the past, for the general aim appears to me to have been good. What I do find fault with is, the way of carrying the experiments out; that is, I blame the plan rather than the object. Experiments on the manuring of particular crops may be perfectly good ones if the manures used are such as are readily procurable, but if they are expensive chemical manures the object may be deprived of any practical outcome by the plan being bad. The comparative produce of a crop under different systems of cultivation, different methods and times of sowing, different depths of ploughing, varying amounts of watering, &c., may form a fitting subject of enquiry; so, also, may the influence of the selection of seed and of change of seed, the out-turn of crops, the growing of new crops and new varieties of crops, the trial of new implements, &c. The general line that experimental enquiry should take is to exhibit side by side a local practice or native system, be it of cultivation or of mechanical device, and another practised elsewhere in India or introduced from abroad, and then to see which one is the most successful in its results.

Then there are more extended but very necessary enquiries, such, for example, as that which Mr. Ozanne originated at Bhadgaon, on the feasibility and cost of establishing "Fuel Reserves;" and, again, the more extensive one of the breeding of cattle.

474. *Seed-growing and Cattle-breeding at Farms.*—But there is

Farms as seed-distributing centres and cattle-breeding Farms.

still another purpose which Experimental Farms, in the broad sense, can usefully fulfil, viz., that of becoming centres for the growth and distribution of pure and selected seeds, and for the location of stud bulls, as well as, in some cases, for the breeding of cattle, and the distribution of bulls to the districts around. Objects of this kind would have to be carried out on an area apart from the more specially experimental one, but they might very well, where opportunity serves, form adjuncts to an Experimental Farm, and could be worked concurrently with the latter under the one supervision. This is actually done, so far as seed-growing is concerned, at the Cawnpore Farm, whilst, at Bhadgaon, cattle-rearing is an important part of the work of the Farm. Reference to these has already been made in Chapter XIII., paragraph 310, and in Chapter XI., paragraph 257. At Cawnpore a separate area of 12 acres, attached to the Experimental Farm, is utilised for growing cereals for sale as seed, and another area of over 50 acres is kept as a fruit and vegetable garden.

It is certainly one of the most useful functions that a Government Farm can serve, to act as a seed-distributing centre, and, where conditions are favourable, as a cattle-breeding farm also, and both these objects might often be carried on concurrently with the more special work of experiment.

Demonstration Farms.

475. *Demonstration Farms.*—There are other Farms which, though not experimental in character, are so closely allied to Experimental Farms as to call most suitably for treatment here. These are the "Demonstration Farms," to which reference has already been made. The purpose of these Farms would be to show, on a practical scale, the result of what has, by experimental trial on the smaller scale, proved to be beneficial. By means of them the advantage of a better mode of cultivation, of a new crop, or of an improved implement, could be set forth, and be brought home to the cultivators. It is not enough to have an Experimental Farm alone, but along with it should go a Farm for demonstration purposes. In this respect there is a decided difference between India and England. In England the farmers are the demonstrators, and they are the distributing medium, but it is not so in India, and what is wanted is the connection between the Experimental Farm and the *raiyat*. This it is which a Demonstration Farm can supply, and it should be the means of bringing to the very door of the cultivator practices and processes which have been proved experimentally to be better than his own. In this way the superior cultivation of one locality may be transferred to another where inferior cultivation prevails.

A Demonstration Farm should be expected to pay its expenses, inasmuch as it is intended to show what is the most profitable practice. At the same time a certain allowance must be made for the extra expense of hired labour, against which, on the other hand, must be put a fair subsistence amount for the *raiyat* and his family, who would otherwise be occupying the land.

Experiments and demonstrations upon private lands.

476. *Private Farms.*—In some cases it may be possible to induce cultivating landowners to undertake experiments on their own land, or it may be advisable, instead of having a separate Demonstration Farm, to have the demonstration carried out upon a field in the actual occupancy of a tenant. If the latter be done, it may be necessary to guarantee the tenant against any possible loss arising from his having undertaken the trial, and to award him compensation for any loss of crop resulting from his having done so.

Where a private individual undertakes an experiment in this way, or gives his land for demonstration purposes, the portion devoted to this object should be under the notice and control of the Director of Agriculture, or of the expert assistants acting under him.

Judging from the number of instances in which landowners have already given part of their land for experimental purposes, alike in Bengal, the North-West Provinces, Bombay, and Madras, it is not likely that there will be any difficulty in obtaining whatever land is required.

In the North-West Provinces there are no less than six private farms used either as Experimental or Demonstration Farms. One of the largest is at Meerut, and belongs to Rai Bahadur Debi Singh; another near Cawnpore consists of 165 acres, and is conducted by Mr. Lachman Parshád, Personal Assistant to the Director of the Agricultural Department, North-West Provinces.

It has been urged with much weight that Court of Wards' Estates could well be made Demonstration Farms, for exhibiting what is found successful at an Experimental Farm, and of thus bringing the results to the cultivators' doors. This, it seems to me, might very well be done.

Another class of farm on which experiments, both with crops and with implements, might be conducted, is comprised in the farms attached to Government Breeding Studs, such as those at Saharanpur, Hapur (near Meerut), Hissar, and elsewhere.

Individual Experimental Farms.

477. It now remains for me to briefly review the different Experimental Farms which I visited. I do not purpose to go exhaustively into a detailed account of the different experiments then in progress, still less into the past history of the several Farms. What I wish to do is to remark generally upon the more prominent points that struck me when I went to each Farm.

Cawnpore Farm (North-West Provinces).

478. *North-West Provinces.*—Cawnpore Farm:

The first that I will take is the Cawnpore Farm, partly because, after the Saidapet Farm (now practically abolished) it is one of the earliest Experimental Farms, and partly because it is the one which I visited most frequently, and followed most particularly. Indeed, I made it a point to watch here the different crops at all the various seasons of the year.

Like many of the other Farms, and in spite of the representations made by those who carry it on, the Cawnpore Farm is still generally known as the "model farm." It has been pointed out that it neither aspires to be a "model," nor yet is it a "farm" in the ordinary acceptation of the term. It is in reality an "experimental station" in the true sense, to which is added a certain area for the purpose of growing selected seed. As such, I am ready to say that I consider that the Cawnpore Farm fulfils well the purpose of its establishment. It is a well-conducted Experimental Station, in a convenient position, and with a suitable soil; and, though faults in detail may be found with it, the general conception and working of it are thoroughly good. The Cawnpore Farm is, I think, more like what an Indian Experimental Station should be than any other I met with in the country, although its younger rival, Nagpur, bids fair in some respects to threaten its leading position. The good work done at the Cawnpore Farm is due, in great measure, to the succession of good men who have had the oversight or the actual charge of it. From its inception in 1874 through the energy and interest shown by Sir John Strachey, it can claim to have had in the past the help of such men as Sir Edward Buck, Mr. J. B. Fuller, and Colonel Pitcher; while, at the time of my visit, under the charge of Mir Muhammad Husain it continued to do good and useful work. In fact I was much pleased with the Cawnpore Farm, and was not prepared to find in India anything which so nearly came up to my idea of what an Experimental Station should be. It is well to note, after the disparaging remarks that I heard about this and other Farms, that I found the crops to be a great deal better than those on the adjoining fields belonging to the cultivators around. On one side a wire fence divided the fields of the Farm from those of the cultivators, and the superiority of the Farm's crops was most marked.

One way in which the Farm shows that its design has suffered is, that it bears the marks of more hands than one having been at work. An experiment has suggested itself to one Director or Assistant Director, and has been carried on for a time, and then been dropped or modified by another Director. This is the fault of a non-continuous system of direction or supervision. A Report upon the operations at the Farm is now issued once every year, though formerly a separate Report was given for each season.

The Farm was started in 1874, and comprises 42 acres of experimental farming, and 65 acres of fruit and vegetable gardening. Included in the latter are 12 acres put in cereals for the purposes of growing seed for distribution. Attached to the Farm is also a workshop where ploughs, pumps, and other implements are made and sold, and where a collection of implements, both of Native and of European make, are exhibited.

The main objects aimed at by the Farm are:—

1. To try new methods of cultivation, and to compare them with indigenous ones.
2. To ascertain the probable out-turn of crops for each year.
3. To try new crops and new varieties of crops.
4. To ascertain the effect of manures upon particular crops, and to try the value of new manurial agents.
5. To test new implements.
6. To grow and distribute selected seed.
7. To make and sell improved implements.

The farm is very well placed; it is ready of access from Cawnpore, and yet is in the midst of cultivation; the soil is very typical of a large area in these Provinces, and the position of the experimental field is all that could be wished. The cultivation is thoroughly done, and I am fully satisfied as to the care that is taken to ensure accuracy in all details. I was present, in April 1890, during the threshing of the cold-season (*rabi*) harvest, and nothing could have been more carefully carried out. In fact, I would be inclined to say that it erred rather on the side of over-refinement.

Without going into details of the many experiments which I saw in progress, I will just pass a comment here and there as it may suggest itself. In what is termed the "Standard Series Manure Experiment" a cold-season (*rabi*) crop, viz., wheat, and a rainy-season (*kharif*) crop, viz., maize, are grown year after year, the same manures being applied each time. This experiment has the great advantage of being carried out in duplicate, and the plots, which are 13 in number, are of fair size, viz., 400 square yards each. The manures tried are cow-dung, cow-dung ashes, sheep-dung, poudrette (night-soil), saltpetre, gypsum, bone-dust, and bone-superphosphate. The only one that seems out of place is the bone-superphosphate, the day of artificial manures being still distant, but all the others are obtainable by the *raiyat*. There ought, however, to be two "no manure" plots, and not one only, in order to check inequalities in the land, and it would be well, too, to give the average of the duplicate plots in each case. The statement of results occupies no less than 17 different columns in each separate table, a needless and complicated way of putting them. The object should be to set out the results as concisely and with as little extra statement as possible. It is of no particular interest to know the weight of grain or stalks on a *plot*, or the percentage of grain to stalk; it is enough to state the results of grain, stalk, &c. on the acre. In the Woburn (England) Experiments the return runs thus:—

Plot.	Manure per Acre, and Cost.	Produce per Acre.			
		Dressed Corn.			Straw, Chaff, &c.
		Weight.	Bushels.	Weight per Bushel.	

For reasons I have given before, I do not approve of assuming, as is done at Cawnpore, a money value for the crop, but I would leave each person to take the figures obtained and apply them to his own case.

In a miscellaneous manure series on wheat, manures such as brick-kiln refuse, silt, compost, road-scrapings, ashes of weeds, and ammonium chloride are tried one against the other, with the object, it is said, of determining the value of refuse not ordinarily used by Indian agriculturists. So far as ammonim chloride goes, it might be added, "nor likely to be used by Indian agriculturists," for this form of ammonia is about the dearest of all, and as to the other materials, they would never be alike in any two districts, and the experiment can only have a local value, if even that. I do not consider this a good experiment.

Miscellaneous manures used on maize comprise woollen refuse, sheep-dung, cow-dung, poudrette, horse-dung, pigs'-droppings, and saltpetre. Woollen refuse gives the best return by far, but, as I said earlier in this chapter, it is not a manure which the *raiyat* can obtain, and the Farm uses up all of the local production, so the information from the experiment is not of any practical value. It is very doubtful, too, whether horse-dung and pigs' droppings as *separate* manures have a practical value either. There is no duplicate unmanured plot here.

A series of *green-manuring* experiments on wheat is designed to show the value of indigo and hemp as preparatory crops, and when ploughed in as manure, also of indigo refuse (*seet*), and of the refuse water from indigo and hemp manufacture. So far as the previous cropping and also ploughing-in go, the experiment is good, but the indigo refuse is only procurable here and there, while the composition of the refuse waters must vary very much in each separate instance. I do not notice that any care was taken to put on the comparative plots the same amount of ordinary water as was supplied in the refuse waters. In this experiment there are, very properly, duplicate unmanured plots.

The last of the permanent series of experiments, the foregoing being all carried on year by year, is one upon the effect of ploughing for wheat with native ploughs and with "improved" ploughs, to different depths. This is a useful experiment, but the plots, being only 300 square yards, seem to me rather small to accurately test cultivation operations of the kind. I would prefer to see it done on a considerably larger scale, as the frequent turnings and treadings on a small plot are likely to affect this result.

After these permanent experiments follow a number of others of more or less temporary duration, upon which I need not dwell long.

Maize is grown on the American plan, as against the indigenous system; also the difference between early and late sowing is tested. The early and late sowing of cotton, and the out-turn of 11 different varieties of imported cotton seed, are tried, and both form useful experiments, though the plots on which the varieties of cotton are grown are somewhat too small to test the question of out-turn thoroughly.

With sugar-cane, different methods of sowing, including indigenous ones, are compared; the yield of different varieties of cane, and the value of cane left for a second year, are tested.

Experiments upon indigo include trials of the use of gypsum as a manure, and the difference of early and late sowings.

Manurial experiments upon wheat are made with cotton-seed cake and mustard cake, as against ordinary cow-dung and dung made by animals fed with cotton seed.

Then there are further manurial trials with kainit and woollen refuse on wheat, but the value of these is very doubtful, for kainit would have to be imported, and, owing to its being the poorest form of potash salts, it would be the dearest for which to pay transport; besides, it seems absurd to import kainit from Germany, with only about 23 per cent. of sulphate of potash in it, when commercially pure nitrate of potash (saltpetre) is made in India itself. Woollen refuse, too, is not a procurable manure in any quantity.

Better than the last is an experiment on different varieties of wheat, the outcome of which is, that a great deal of Muzaffarnagar wheat (soft white) is grown for distribution, and also Sindhi, a hard white wheat, which grows very high and is a late variety.

Varieties of barley have also been tried, and a white huskless variety has been very successful.

Lastly, manurial experiments have been made with gypsum upon leguminous crops, and with poudrette, woollen refuse, kainit, gypsum, and castor cake upon potatoes, the latter manure being, as before, open to the objection attaching to woollen refuse and kainit; the experiments are satisfactory in most other respects.

The above, with a few others, comprise a long and, on the whole, a very useful list of experiments, entailing a great deal of labour and care, but, so far as I could see, very well carried out, and designed to bring out the main points to be served by experiments, viz., the comparison of a suggested with an existing practice.

In addition to the above, there have been attempts from time to time to introduce new crops, such as Guinea grass (*Panicum jumentorum*) for fodder, and the variety of *Sorghum saccharatum* known as *sorgho*.

The general out-turn of crops has been estimated from plots grown on the Farm, in order to check the forecasts made for the Provinces. But this is not satisfactory, for so much depends upon whether the land has been watered and manured or not; at Cawnpore, cattle-manure is used, and canal irrigation is available. The general out-turn of wheat in 1888–89 was about 22 bushels per acre over the Farm.

Implements have been extensively tried at the Farm, including different kinds of sugar-mills, sugar-evaporating machines, ploughs and pumps. These have been referred to in Chapter XII., paragraph 286. The extensive seed distribution carried on has been spoken of in Chapter XIII., paragraph 310. Another useful purpose which the Farm has served is, in having been the training ground of a number of apprentices who have subsequently gone out to other farms.

The Assistant Director, in summing up a recent Report, expresses his belief that the Farm has a real, though possibly slow and limited, influence on the native agriculture. People often come to see it, and the services of farm apprentices and labourers are often borrowed. Thus, one was sent from here to the Central Provinces, to teach the making of the unrefined sugars termed *gur* and *rāb*. Apprentices also come from other places to learn on the Farm.

The Farm Report (I refer to that of 1888–89) has a good and clear description of the experiments and their aim. I would point out that its chief fault is the complication of the results by the giving of so many columns in the tabular statements. Again, it would be well to adopt greater uniformity of nomenclature; for instance, in several cases, *bighas* and acres are mentioned together, and in other cases *bighas* and square yards.

The danger, as regards the future, is, that, owing to the large number of *manurial* experiments, the land will be affected so unevenly that it will be a difficult matter to find space for fresh experiments when needed, or, what is worse, the results of the trials will not be accurate, owing to the difference in the previous treatment of the plots composing them. I hardly think that *manurial* experiments are the most important ones in India, for the difficulty is to get manure of any kind whatever. I would rather see more space given to experiments in methods of cultivation. There should also be a reserve of land kept over, treated and cropped each year much alike; this would serve for the extension of experiments as required. I should also like to see considerably more duplication of experiment. It is not so important to get a large number of results as to make sure that those given are correct, and this can only be verified by repeating them, not only on the same spot but on fresh land, and in a succession of years.

It seems to me that the Farm might well be made use of as one at which stud bulls could be located for the breeding of good farm cattle. There are great complaints in the neighbourhood that the Brahmani bulls are getting scarcer and scarcer, and the Farm might in this way supply the deficiency.

479. *Gardens at Saharanpur and Lucknow.*

Gardens at Saharanpur and Lucknow.

Not altogether of the nature of Experimental Farms, though in their origin intended to be more or less so, are the gardens at Saharanpur and Lucknow. Formerly, experiments were carried on at these, but little of this work now remains, the gardens being worked on a commercial basis, and being really only used for the sale of plants and seeds, the supply of drugs to Government stores, and for the training of gardeners.

Some experiments have been tried on the acclimatisation of English varieties of wheat, on the growing of the date-palm (*Phoenix dactylifera*) and other plants, but now there is hardly any of this work done, and though they form pleasant recreation grounds, and do good in providing plants and seeds for sale, the gardens can hardly be classed as Experimental Farms, but only as Nurseries, which, in India take the place of those of the florists and seedsmen of England.

480. *Central Provinces.*—Nagpur Farm:

Nagpur Farm (Central Provinces).

This is one of the more recently formed Stations, it having been started on its present plan in 1883, although previously to this a large "model farm," as it was called, of nearly 400 acres had existed. The present Farm is about 90 acres in extent, 67 acres being experimental, and it is based upon the model of the Cawnpore Farm, this being accounted for by the transference of Mr. J. B. Fuller from the North-West to the Central Provinces about that time. The out-of-pocket expenditure on the Farm in 1888–89 was Rs. 3,744, and in 1889–90, Rs. 6,801. this latter including the superintendent's pay, not before reckoned in. The Farm is well placed, being amid cultivation, and yet conveniently situated as regards the town of Nagpur; the field is level, the plots are of a fair size, and the soil is typical of large tracts of better-class land in the Provinces. If I took any objection to it, it would be on the ground of the soil being rather too rich for an Experimental Station. In the case of India it is better, however to have land which is representative of the district than to have soil more distinctly suited to scientific experiments.

The Farm generally, and the experimental plots, were evidently well and carefully cultivated, the whole was in good order, and a close examination of the Reports leads me to conclude that the results are accurately and faithfully recorded.

The present Manager is Mr. Mahaluxmivala, a careful and competent man, who takes much interest in the work of the Farm.

This Farm and the Cawnpore Farm more nearly approach what an Experimental Station should be than any of the other Farms which I saw in India.

Cotton is the chief crop of the Central Provinces, and so it is natural that experiments should be largely concerned with it.

The first series is a manurial one upon cotton. Ordinary cattle-manure, poudrette (night-soil), and bone-dust are tried. There are several duplicate unmanured plots ; but in the statement of results neither the quantity of manure (in 1888–89) nor its cost per acre are given. On the other hand, details such as the area of the field, the serial number of experiment, the number of hand-weedings, and the number of bullock-hoeings might well be omitted. The plan of the experiment is good, and (I refer to the 1888–89 Report) the results are consistent, and would show the soil to be suitable for experiment.

The next series is termed "green-soiling on cotton," hemp being the crop used as manure. By "green-soiling" is, however, properly meant that a crop is grown and fed off on the land, generally by sheep. What was done here was green-manuring, *i.e.*, the ploughing in of a green crop preparatory to putting in the corn crop that preceded the cotton. In this case, again. there are duplicate reference plots. The results of this experiment are not conclusive, and their publication might with advantage have been deferred.

Trials were made with cotton seed prepared for sowing by steeping it in sulphuric acid, to remove the wool, as against the native practice of steeping it in cow-dung and water. The same was done in 1886–87, the results being then unsatisfactory, but in 1889–90 they seemed to give some evidence of benefit accruing from the sulphuric acid treatment. Further confirmation is clearly needed before more can be said.

After this follows a manurial experiment upon *til* (*Sesamum indicum*). The experiment, however, hardly starts on a fair basis, for these same plots, with the same manures each year, had been previously used for a permanent series with wheat. Consequently the plots did not begin level, and the experiment is rather one upon rotation than on the *til* crop alone. So little, too, is known about the *til* crop or about the manures likely to benefit it, that I should consider it better to take fresh land, and not that upon which manures had already been used for a number of years previously. I should also be inclined to regard *til* as not a very suitable experimental crop. Great anomalies are seen in the returns, owing, I believe, in great measure, to the previous manuring and to the unsuitability of the crop. In 1888–89 bone-dust and saltpetre gave a less produce than either used alone, and in 1889–90 cattle-dung and bone-dust gave less than cattle-dung alone. It is possible that bone-dust has done no good, but I do not believe in the possibility of its doing harm. There was no duplicate unmanured plot.

In another case *sorgho* (*Sorghum saccharatum*) was grown for the purpose of making sugar, but very little crystallisable sugar was obtained.

Experiments on silage-making with *juar* (*Sorghum vulgare*) and Guinea grass (*Panicum jumentorum*) were rather more successful, but the losses, amounting to 33 per cent. in one case and 49 per cent. in another, between the weights of green stuff put in and the silage taken out, are far too high. Where silage is to be made every year, I would certainly advocate brick or masonry silos in preference to those merely dug in the soil, which have only earthen sides and bottom.

The out-turn of crops is gathered from other plots on which some 12 different crops are grown. So much depends, however, on the soil and the manuring given that the results are but of limited value.

With cold-season (*rabi*) crops trials have been made on the effect of embanking land in the case of wheat and linseed. The results are not encouraging, but the native method had not been properly studied previous to the commencement of the trial.

Green-manuring, or green-soiling, as it is inaccurately called in the Report, has been carried out with wheat and linseed, and in another part different manures, such as bone-dust, gypsum, dung, and hemp, have been tried. In neither case are the results properly comparable.

The most satisfactory series has been the permanent one on the manuring of wheat, this crop having been grown year after year, with the same manures each year, these being, all of them, such as might well be used for wheat. The existence of this experiment in duplicate adds much to its value. What is wanting in the statement is the cost of the manures. The duplicate experiments agree very fairly with one another, several distinct issues are brought out, and the influence of season is checked by the repetition year after year; altogether, the experiment is a very good one.

The averages are also given for the past five years, and the following interesting comparisons with the Woburn (England) experiments for 10 years may be drawn :—

—	—	Manures per Acre.	Produce of Wheat. Bushels per Acre.	Produce of Straw. Cwt. per Acre.
1	Nagpur -	No manure - - - -	13	9
	Woburn -	- ditto - - -	17	17
2	Nagpur -	Saltpetre, 240 lbs. - -	19⅓	14
	Woburn -	Nitrate of soda, 275 lbs. -	24	25
3	Nagpur -	Cattle-dung, 6 tons - -	14⅓	—
	Woburn -	Farmyard manure, 4 tons -	21	—

In the returns no attempt has been made (and I think wisely) to assign any money value to the different yields. I do not like, however, the method of returning the produce as "percentage of increase over produce of unmanured plot;" it would be much better to simply give it as "increase per acre over unmanured produce."

An experiment more of the nature of scientific enquiry is that termed "the Ville series" on wheat. A complete manure, composed of ammonium chloride, superphosphate of lime, sulphate of potash, and sulphate of lime, is used on one plot, and on the others *one* of the ingredients is in succession omitted and the rest put on, the object being to see which constituent it is that the plant requires most.

In addition, trials have been made with different sugar-mills; different varieties of wheat have been grown; selected cotton seed has been distributed to cultivators; and a limited number of new implements have been sold.

But one of the chief functions which the Farm performs is that of being the training and instruction ground for the Agricultural Class, of which further mention will be made in the next chapter.

The Nagpur Farm has not had the advantage which the Cawnpore Farm enjoys, of being old enough for the character or the qualities of the land to be sufficiently brought out, and there is still a good deal to be learnt about it before experimental work can be fully satisfactory. Besides this, the soil does not appear to me so well suited as the Cawnpore one to the purposes of experiment. In general, the plan set forth is good, and the details are accurately carried out, but the results require a good deal of careful sifting before it can with any safety be stated that a definite conclusion is warranted.

At the close of the Report is a summary or "comparative record" of results. This is done in accordance with the recommendations of the Agricultural Conference which met in Calcutta in 1884, but this summary is, I think, both useless and misleading. The same result is made use of over and over again to institute comparisons, even where the conditions have been quite diverse, and the consequence is, that if a conclusion be faulty from any reason, it is brought in time after time, and may lead to other faulty conclusions being drawn, even where the immediate premises are good.

Bombay Farms.

481. *Bombay Farms.*—The Bombay Government owns two Experimental Farms, one at Poona, the other at Bhadgaon, near Pachora, in Khándesh. But neither is experimental in the full sense, the Poona Farm being used mostly for educational purposes in connection with the agricultural branch of the Poona College of Science, and the Bhadgaon Farm approaching more to a "Model Farm" than any other in India, and being also devoted largely to the breeding of cattle.

The Farms are the outcome of the movement in 1869 to establish "Cotton Farms" in India. At the time of the American Civil War attention was turned to India as a main source of the future cotton supply, and, accordingly, "Cotton Farms" were established throughout that country under the charge of men sent out from England, but who, as a rule, were really nothing better than gardeners. After the Civil War was over, the cotton trade returned to its normal state, and the Farms then became Model and Experimental Farms, and were transferred in 1873 from the Cotton Commissioners to the Provincial Governments. In a few cases the "cotton farmers" brought over were retained as Managers of the Farms, but in most cases they were found unfitted for the duties.

Bhadgaon Farm.

482. *The Bhadgaon Farm*

comprises 1,200 acres, of which only 65 acres are experimental, and 600 acres are cultivated in the ordinary course, the remainder being grazing and pasture land. In 1888 the loss on the Farm was Rs. 990, not including the Superintendent's pay of Rs 3,000; in 1889-90 it was Rs. 3,743, including the Superintendent's pay. This, therefore, represents the net cost to Government.

It is not an Experimental Station in the sense that Cawnpore and Nagpur are, but is really a farm where improved cultivation is attempted, where cattle are bred, and where, now and again, a few experiments are tried over a limited area.

Regarding it simply as a farm, I may express my opinion that I think it is carried on very ably, and that it is doing genuine good work, although the results may be slow in showing themselves. In regard to crops grown, there is a striking superiority over those of the cultivators around, and in this respect the Farm may rightly be termed a "model" one. Mr. P. R. Mehta, the Manager, and a Diploma holder from Cirencester, is a capable and thoroughly practical man, who takes great interest and displays much assiduity in carrying out the work. He is one who can and does turn his hand to anything that is required on the Farm, and is himself no mean "cattle doctor." I was greatly pleased with the Bhadgaon Farm as a general though not Experimental Farm, and I think that it is most creditable that the expense incurred by it is so small as it is. The amount spent is really very trifling, and the advantages it is likely to afford in the future as a training ground, when agricultural education is more developed, will be very cheaply obtained. I am quite sure that few of those who complain of the expenditure incurred can have been at the Farm, or have taken the trouble to see how it is actually worked, or how favourably it compares with the cultivation around. Least of all can they have seen the excellent herd of cattle, or have noticed, as they might most certainly have done, the impress which it is beginning to make upon the stock of the district. There are respects, undoubtedly, in which the Bhadgaon Farm might be improved, but it is, I am confident, an institution of which the Bombay Government and Agricultural Department may very well be proud. It is surprising to me that the expenses are so nearly met, for it has to be remembered that the produce of the different fields is all gathered separately, and thrashed and weighed separately, many records have to be kept, and hired labour has to be employed. If the crops could be all put together, and thrashed and stored at once, the Farm would be able to pay its expenses quite well, but then it would be a pity to lose the information that can be obtained here. Seeing this, I do not think that the Superintendent ought to be needlessly tied down by considerations of cost. It would be much better to devote annually to the Farm a certain sum which past experience has shown it to require, and so long as the Farm is conducted as at present, the Bombay Government may be assured that the money is not being uselessly expended. It is reckoned that about Rs. 5,000 year are wanted, and I should not call this out of the way, seeing that the out-of-pocket expenditure on the Woburn Farm of the Royal Agricultural Society of England amounts to nearly 600 *l.* annually, and the acreage is about the same as at Bhadgaon. I cannot help noting the tendency of Commissioners and Collectors, and Under Secretaries, who report on the Farm, to devote their remarks principally to the *financial* side, and to say but little as to the way in which the Farm is influencing the agriculture, and more especially the cattle, of the neighbourhood.

I need not say more than I have given in Chapter XI. (paragraph 255) about the cattle-breeding operations at Bhadgaon, in order to show that the Farm is doing good. The readiness of the people to buy the young stock is a proof that the operations are appreciated. It is to stock-breeding purposes that the Bhadgaon Farm should be more particularly devoted, and this has now been recognised by the Government. Forty acres of land have been set apart for field experiments, but beyond this it is not intended to carry on unremunerative trials. This area has, very properly, been sown all over with the same crop, in order to equalise it before beginning any regular experiment. Such experiments as have been conducted have been upon the growing of different varieties of cotton, different kinds of wheat and barley, the pickling of grain, the prevention of weevil in grain, and the growth of special crops and trees, such as arrowroot, *divi-divi* (*Caesalpinia coriaria*, a material used in tanning), mangoes, and guavas, as also on the making of silage and the trial of certain implements. More recently an experiment has been started on the cost of establishing a "fuel and fodder reserve." This I have referred to in Chapter VIII. (paragraph 186). Silage has been made without difficulty, and since I left India the experiment has been tried to make a "stack silo" in the open, instead of digging a pit in the ground. Mr. Ozanne, the Director of the Agricultural Department, is endeavouring to keep up the supply of pure *bani* and *jari* cotton (Berar long-stapled varieties) by growing them at the Farm, as also American varieties which have been acclimatised at Dhárwar. A certain amount of selected seed of different kinds is yearly distributed from the Farm, and there are seven iron sugar-mills which are let out on hire in the district. Goats thrive well at the Farm, and have now replaced the sheep with which it was intended to try improvements. The cattle are a pedigree herd of the Mysore breed, known as *Khillari*, and Malvi cows are kept as nurse cows. A Government stallion (Arab) is also located here, but is not much appreciated as yet.

A great fault of the Farm is its isolation; it is hard to get to, and consequently cannot be easily visited. Half-a-day's journey has to be taken from the nearest station, and several rivers have to be crossed or forded. The Farm is unnecessarily large, and is not suited as an experimental area. The distance from any large town makes the sale of the produce not so remunerative as it would otherwise be. In many ways the cultivation is superior, and I noticed here an attempt made to preserve the cattle-manure. A large quantity is made and kept in a pit, but it might be improved in quality if better stored, turned over occasionally, and then heaped together more closely; it was allowed to lie too loosely and to become too dry; a large amount of straw and stalks, which might quite well have been used for litter, was left in a dry state, and not mixed up with the cattle-droppings and so allowed to decay, while the urine from the sheds was wasted to a considerable extent, and during the rainy season it mingled with the rain water from the spoutings of the sheds. It would be much better to spread the dry stalks, straw, or even fine earth, under the cattle, and thus to soak up the urine. By showing how this could be done, Government Farms like Bhadgaon might prove good practical examples.

There is an educational purpose that the Bhadgaon Farm might usefully fulfil. It would be a capital place at which to send into residence for a time the agricultural students of the Poona College. Here they might see carried out on a practical scale what they had learned theoretically, and they might do the actual farm work themselves at Bhadgaon. A practical class of this kind, following upon the instruction given at Poona, would be of great benefit.

The Bhadgaon Farm might also be utilised as a place to which apprentices might come and receive a practical training before going out to act as managers of estates, or to look after their own landed property.

Poona Farm.

483. *The Poona Farm,*

as I have said, is not an Experimental but rather an Educational Farm. Different crops are grown, and their yield is estimated; a few cattle are kept, and an attempt has been made to estimate the relative milking properties of different breeds, but on a scale far too small to be of any use. What experimental work has been done has not, it appears to me, been directed to any special end; as the manager told me, he has to get as much out of the land as he can, and it does not *pay* him to try experiments. The whole area of the Farm is 66 acres, and it is very conveniently placed as regards the town and the College of Science.

Silage has been made here, but no light is thrown on what the cost has been, or whether the system is remunerative. The manure from the cattle is very badly stored, the urine is almost entirely wasted, and the manure heap is little more than a dry rubbish heap. A great improvement in this respect might be made, more especially at a place where students come for instruction.

In one case a comparison has been tried between Khándesh *juár* (*Sorghum vulgare*) and the local kind grown, but, as the previous crop was partly sugar-cane and partly gram (pulse), the plots did not start under level conditions.

As a place where the students of the College can come and see different crops grown, and become familiar with them, and with the outlines of farm operations, the Poona Farm has an educational value; but, inasmuch as the students do not work on it themselves, it would seem to me very desirable that during their course they should be sent to the Bhadgaon Farm, where they could see the work carried out on a practical scale. It should also be mentioned that at Poona Mr. Ozanne has got together a very complete collection of native agricultural implements.

There used to be another Farm at Hyderabad, in Sind, but there is no longer a Government Farm, it having been given up in 1889. The experiments here were of no value.

Nadiad Farm.

484. At *Nadiad, in Gujarát (Bombay),*

there is a Farm of 12 acres, inaugurated in 1878, and kept up by the Agricultural Association. It is made use of in connection with the Agricultural Class attached to the High School. The soil is a rich red garden loam, and very deep.

Manurial experiments form the principal work. These are upon *rági* (millet), *tur* (pulse), and *juár* (millet); also an extensive series upon tobacco, to which reference has been made in paragraph 368. Different varieties of cotton, American and indigenous, as also of the castor-oil plant, are tried. Male buffaloes are used in ploughing, a practice not locally adopted, but which it is sought to introduce, and iron ploughs are also employed. There is a museum attached to the Farm, containing specimens of cotton, cereals, &c., and in the town is a seed store, maintained by the Association, where pure seed can be got by cultivators. The Farm is given rent-free by Government, so long as it is available for the Agricultural Class; the yearly expenses, amounting to Rs. 400, are more than covered by the out-turn. The Association hold a Cattle Show biennially at Nadiad.

Farms in Baroda.

485. In the *Native State of Baroda* experimental work bids fair to make a good beginning, for not only does his Highness the Gaekwar take a great interest in agriculture, but he has also secured the services of Mr. Middleton, formerly a distinguished agricultural student at home, as Professor of Agriculture at the Baroda College. In company with Mr. Ozanne and Mr. Middleton I went over the proposed Experimental Farm, and I need but say that I am sure that what Mr. Middleton does he will do well, and his presence in India will be a distinct gain to agriculture in that country. As the experimental area had not been taken up when I was there, it is of no use for me to refer further to it, except to say that I look to much good resulting from it, as Mr. Middleton is, perhaps, the first man who has come out to India who has combined a practical acquaintance of agriculture with good general knowledge of agricultural science.

When at Baroda I also visited another Experimental Farm, as it was termed, carried on by Mr. Kacherao Jadhava, an ex-student of the Royal Agricultural College, Cirencester. An Agricultural Class is supposed to come here for practical instruction, and at the time of my visit I saw the students working away on plots a few yards square, which had about a dozen plants of some crop growing on them. All looked pretty enough, but I could not say more. Attached to the Farm was a wonderful collection of implements, gathered, I should say, from all parts of the world, and at great cost, too, but with utter disregard to the conditions of Indian agriculture. Here, for example, was a huge waggon from Germany, used in that country for bringing brewers' grains and beet-root pulp from breweries and distilleries, and requiring, perhaps, some six horses to draw it! Here, too, were huge iron seed-drills, heavy iron ploughs, manure distributors, and seed-barrows for sowing clovers and rye grasses among barley. Mr. Kacherao also had a chemical laboratory is the town—at least, there was a very complete set of chemical apparatus there, if nothing else.

This Farm and its belongings must have cost a very considerable sum, and I should like to have seen the money better bestowed in the cause of agricultural improvement.

Fruit farms.

486.

In addition to the Farms in the Bombay Presidency here mentioned, there are fruit gardens at Ganesh Khind, near Poona, comprising 80 acres, and devoted to the growing of mangoes, and more especially to the propagation and sale of grafted mango trees. This culture is also carried on to a more limited extent on a part of the Poona Farm. A large quantity of grass is cut green from off the Ganesh Khind plantations.

Future plan in Bombay.

487. The plans for future experimental work in Bombay comprise the establishment of a Stock and Dairy Farm at Alegaon and the starting of new Experimental Farms of small extent in five or six different districts of the Presidency, notably the Southern Mahratta country, the Konkan, and Gujarát. The object of these is to test in one locality the results obtained at others, and so to establish their value in relation to the different conditions and soils that occur throughout the Presidency. With the view of supervising these, a European Superintendent of Farms has been appointed, whose special work it will be to look after the Farms and the experiments at them. Against these proposals I have no decided objections to urge, so long as it can be clearly established that a distinct need exists for the Farms; but on this I can hardly give an opinion. The wants of one district will not be those of another, and crops and methods of cultivation will differ too. If arrangements can be made for efficient supervision, and if, as I have said, a *primâ facie* case can be made out for the establishment of a Farm, or for the testing of any particular local practice, then there is the warrant for its existence. But unless the object be clear and unmistakable, and the necessity for experimenting in a particular district be shown, I do not regard the starting of fresh Farms as advisable. Something more is needed than a "general idea" as to the usefulness of an Experimental Farm.

Madras Farms, Saidapet.

488. *Madras.*—Saidapet Farm. The earliest of all the Experimental Farms was Saidapet, established in 1865. It is also the one on which the greatest attempts have been made to introduce new practices and new implements to the notice of the Indian cultivator. The past expenditure on the Farm has been considerable, and it has now been finally abandoned as an Experimental Station. From 1871 to 1887 it was under the direction of Mr. W. R. Robertson, and was supplemented in 1876 by the starting of an Agricultural College. It is not for me here to go into the past history of the Farm, nor to discuss at length the steps which have led to its abandonment. It is enough to say, in the words of the Director of the Madras Agricultural Department, "The "results attained at the Farm are, so far as the agriculture of "the country is concerned, purely negative; no attempt is made "to connect the one with the other." Undoubtedly this failure to bring itself into sufficiently close communication with native agriculturists has had much to do with the result, but there have been other causes too, prominent among which has been the constant change of policy adopted by the Madras Government towards the Farm, and the refusal to supply it with the necessary funds; yet another has been the unsuitableness of the spot chosen for the Farm. It is, as I have described it elsewhere, little more than a sand-hill, and ought never to have been selected as the site of a Farm. It is too small for stock-breeding, and too poor and barren for crop-growing. It may serve in some ways as an Educational Farm for the use of agricultural students at the Saidapet College, but for little more. At the time of my visit experimental work had been almost entirely given up. From being partly under the Agricultural and partly under the Educational Department, the College is now to be separated from the Farm, and to be placed, along with its Principal, under the Educational Department. The 300 acres of which the Farm originally consisted have now been reduced to 60 acres, and will simply serve the purpose of illustrating the growth of different crops.

The cattle I saw at the Farm were 12 Nellore cows and 16 Nellore and Aden bulls, and they were very good indeed. The bulls are kept for stud purposes, and their services are available, at a low fee, for stock belonging to cultivators, but they are not much made use of. I have mentioned previously an experiment carried out on sheep; four being fed on earth-nut cake with other food, and four without the cake; but I pointed out also how inadequate the number of animals was for the purpose (*see* paragraph 458.)

There is, however, one point that the Saidapet Farm has done very considerable good in showing, viz., that cattle can be kept perfectly well on the "box" system, that is, with litter under them, and that the manure obtained in this way is far more valuable than that got in the ordinary way. During my Madras tour I came to one or two farms where cattle were littered, and manure kept in heaps, well beaten down and covered with earth, and I think the Saidapet Farm has done a useful work in demonstrating the advantages of the system. I am sure that its adoption would be one of the best ways of benefiting Indian agriculture; that is, by making the manure supply more valuable, and allowing less waste to take place.

No Experimental Farm has worked harder than Saidapet in trying to introduce iron ploughs, and here and there (more especially where there has been a considerable area to till, so that time has been a matter of importance) some new iron ploughs are used by landed proprietors; but they have hardly come down to the small cultivators yet, though much ingenuity has been expended on simplifying them, and on decreasing their cost.

Madura Farm.

489. I visited at Madura what was formerly the Experimental Farm of the Madura Farmers' Club, but which has now been given up, except so far as the dairy part of the Farm is concerned. It comprises 30 acres, and was started in 1883, under the care of a student from the Saidapet College. Experiments were carried out with improved ploughs and water-lifts, with fodder-crops and tobacco, and on the breeding of stock. But it does not appear that any definite fresh experience was gained, and interest was soon lost in the Farm. There is, however, a ready sale for milk in the town, and this part of the farming has been kept up and pays well; there are some 14 cows in milk, very fair cattle, some of them Aden cows, the others country stock, and they are fed with earth-nut cake, fodder-crops, &c. The average daily yield of milk per cow is 12 lbs.

Report of Madras Agricultural Committee, 1889.

490. In September 1888 an Agricultural Committee was appointed to enquire into the operations of the Madras Agricultural Department, and the Report of this Committee was presented to, and considered at, the Agricultural Conference at Simla, in October 1890. As regards Experimental Farms in Madras, the Report does not speak favourably. Efforts at improving the breeding of cattle, sheep, and horses have, it is said, not done any real good, nor has anything been introduced in the way of machinery which has taken a real hold upon the cultivators except the Beheea sugar-mill. At the Saidapet Farm the value of deep tillage, and the possibility of growing fodder-crops, have been shown, but very little more, and even these have had but little practical result. The Report indicates that the chief reasons of failure have been the absence of an organised Department, an insufficient staff, imperfect supervision, and the want of knowledge of indigenous practices and conditions. The mistake made at the beginning was, that the *raiyat* wanted teaching, and that all his practices and implements would have to be altered, and that the "Model Farm" was to teach him his business. In place of this, the Agricultural Committee now recommend the abandonment of the idea of teaching the *raiyat,* until, after careful enquiry, more is known as to the native practices and conditions. The committee also advise the inauguration of experiments under the control of trained agriculturists. It is now proposed to have experiment and demonstration carried on at some five or six Farms, each not exceeding 30 acres in extent, in different parts of the Presidency. Each is to be a combined Agricultural School and Farm, or Farm School. The Farms are to be under the management of the head master of the school, who is to be a graduate of Saidapet College, and acquainted with agricultural practice. Meantime the Saidapet College and Farm are to be retained as training grounds for future teachers.

I have already thoroughly endorsed the recommendations of the Committee as to the necessity of abandoning the attempt to teach the *raiyat* until more is known, through careful enquiry, of what his practices really are, and the conditions under which he pursues them. I am not so certain, however, about the advisability of starting at once some five or six different Farms, partly experimental, parly educational or demonstrative, in different parts of the country. If there be efficient and sufficient supervision for them, the plan may be adopted with benefit, if kept to a limited scale, and if the sites be suitably chosen. It is said that there are qualified graduates who have passed out of Saidapet College, and that they could be utilised as Superintendents of the Farms. Of their qualifications for such posts I can hardly speak, but I cannot help noting that the Government Order (No. 515, Revenue, 4th July 1890), which, in paragraph 12, approves of the plan recommended by the Agricultural Committee, also says, in paragraph 11, "special instruction in "agriculture, however, is almost non-existent, owing to the want "of men competent to give it." I should be afraid of the former blunder being repeated, and I think that it would be better only to establish a Farm which is at all experimental in character where there is a positive call for it, and where there is fully competent superintendence. Unless this be the case, Agricultural Education would be better helped by Farms of a purely illustrative character.

Nor can I agree with the recommendation to extend the Saidapet Farm, and to make it more complete and practical. The Saidapet Farm, by reason of its soil and situation, will never be a suitable place for illustrating agricultural operations, still less for trying experiments. And this I say not merely from what I have read or heard, but from what I have seen myself. If asked to start an Experimental Farm there, I should, if possible, decline at once to do so, for the place neither is nor can be, at any reasonable cost, made suitable. A part of it is even blowing sand. I do not at all agree with some remarks made by Mr. Nicholson in his note to the Agricultural Committee's Report, to the effect that, even if the soil be poor, as described, it should be possible to improve it, and to show what the *raiyat* might then do with it, and that if the Farm cannot show this, it has no right to be called a "Model Farm." It must be remembered that there are soils in England as well as in India on which any expenditure on improvement is simply money thrown away; there may be soil that is not worth reclaiming or improving, at least under existing circumstances; the influence of manures and other means of bettering soils depend, for their efficiency, on the *responsiveness* of the soil, and what may be retained on the one may pass through the other, and so be wasted; on certain lands of good productive power it may pay perfectly well to use, say, 2 cwt., or even as much as 4 cwt., per acre of nitrate of soda, costing from 20 *s.* to 40 *s.* an acre alone, whereas on another soil even ½ cwt. of nitrate of soda an acre would be thrown away. Again, a great deal depends upon what the crops may be, and what the market conditions are. An English farmer would not grudge to spend large sums in manure if he could get thereby, say, an early crop of potatoes; but if they came a fortnight later, a loss instead of a gain might result, though the potatoes might in either case be equally good in themselves. So, too, with low prices of a grain crop of ordinary kind, it will not pay to go to any great expense; but if, owing to favourable soil, situation, and other conditions, a superior malting kind of barley can be grown, a good return for outlay is ensured. I have laid it down as a condition of success in experiment that the soil must be fairly responsive to manure and cultivation, and if one has to do with a bare sand or soil like that of Saidapet, the improvement of it is simply the sinking of capital in a medium unworthy to receive it, and incapable of responding to it. The best to do with such land, if it has to be cultivated, is, not to see *how much* can be sunk in it in hope of getting benefit one day, but *how little* need be expended upon it. I maintain that the chief end of experiment is to see how land that is fairly productive can be got to produce more, and not how land that is not fit for cultivation can be brought under the influence of methods and practices applied in England and elsewhere to the increasing of the crop-return. There may be circumstances where the restoration of deteriorated soil is called for; but I do not think that the credit of an Experimental Farm, whose object it is to introduce practices applicable to the *increase* of crop in cultivated and culturable soils, should hang upon the results obtained upon what is little better than a sand hill.

Bengal Farms.

491. *Bengal Farms.*—Experimental Farms in Bengal are three in number, and they are all of recent creation, for, previous to 1884, there was no Director of the Agricultural Department of Bengal. The three Farms are Dumraon and Burdwan, both established in 1885, and Seebpore, started in 1887. I visited Dumraon and Seebpore, but not Burdwan; indeed, the position of the latter is so unfavourable that it is contemplated to give it up.

Dumraon Farm.

492. *Dumraon Farm* covers 15 acres, and is intended to be an Experimental Station in the stricter sense.

The Maharajah of Dumraon pays all the expenses, which, including the overseer's pay of Rs. 600 and rent, amount to a net cost of Rs. 1,200 annually. An overseer was obtained from the Cawnpore Farm, but he can only give partial attention to the Farm, having the charge of other parts of the Dumraon Raj, or Estate, as well. Occasionally, one of the Assistants to the Director of the Agricultural Department visits the Farm, perhaps once or twice a year, but it was evident to me, from the state of crops, that there was a lack of regular supervision.

The first experiment I noticed was one on the growth of sugar-cane with different manures, as well as by trying the Native against the Mauritius plan of sowing. But the sugar-cane crop was growing on land that was too wet and low, and the crop looked very inferior. As an experiment this one was worthless. Again, the manures used had little relation one to the other; they were cow-dung, castor cake, saltpetre, and a mixed manure termed "normal manure." In choosing manures, they ought to be arranged with some regard to their constituent parts, so as to enable an experimenter to gain some information as to whether it be the nitrogenous, phosphatic, or potassic properties, or else the presence of vegetable matter, that proves most effectual; this point solved, more special experiments can be tried with materials containing the particular ingredients. But here the state of the crop rendered comparative results misleading. Where the native and Mauritius system of planting were compared, the question was further complicated by manurial issues as well; this seems to me very undesirable. Single issues should be set out as far as possible, and these only. There were no duplicate plots at all.

The next series was on the manuring of winter rice sown broadcast; 15 plots (a far too large number) were taken up, though in no case with duplication of experiment. Shallow and deep ploughing for rice comprised two of the plots, a slight advantage being attributed to the latter. The manures used were, as before, of a very varied kind, and allowed of no deductions being drawn except as concerned the actual material employed, but supplied no information as to the most desirable class of manure, whether vegetable, or phosphatic, or saline. Green-manuring, cow-dung, lime, saltpetre, oil cake, and sweepings were tried. Saltpetre, either alone or with lime, gave the best returns, but, on going into figures, its use is found not to have been financially successful. This I can well understand, and it seems to me to need little practical demonstration to show that a very readily soluble salt like saltpetre is thrown away upon a crop that grows frequently with an inch or so of water standing on the ground.

Another series on the same lines, but with transplanted instead of broadcasted rice, followed.

The next was on wheat, with the same manures as were used for rice Here, again, saltpetre gave the best returns, though the increase is stated to be year by year a declining one.

I cannot say that I considered the Dumraon Farm a good Experimental Station. The first mistake made with it was to take up the whole area, to divide it into squares, and to cram in as many plots as would well go into the space. The consequence is, that there is no room for extension of experiment, or for re-testing what has been done. Then, as all the experiments are manurial ones, the ground is practically done with, so far as future experiments are concerned, unless with a considerable break of crop-growing without manure.

Next, there is no duplication of plots, and more especially of unmanured plots; nothing seems to have been done to test the suitability or evenness of the land for experimental purposes, and, indeed, the Report says "the "surface of a large portion of the Farm is uneven, and, unless it is properly "levelled, it is idle to expect a uniform growth of crops. As it is, these "may thrive sufficiently well in the hollows, and get stunted and burnt up "in the intervening patches of high ground. The unevenness of the "ground also stands in the way of irrigation." This, to my mind, surrenders the whole point as to the Farm being a good Experimental Station, let alone what I have said as to the absence of supervision and of design in the plan of experiment.

Seebpore Farm.

493. *The Seebpore Farm*

is only a little way out of Calcutta, and includes about 26 acres, of which 18 acres are experimental. The soil is rather heavy alluvial land, with a good deal of clay. It was formerly jungle land. Its depth is about 2 feet, and then it gets more sandy and light. The Farm is in charge of an overseer who originally came from Cawnpore. The Seebpore Engineering College adjoins the Farm, and a roposal is on foot to establish an agricultural branch at the College, and to use the Farm in connection with it.

At this Farm I saw the process of preparing bones for manure by crushing them in the native mill or *dhenki.* It is said that with the *dhenki* three men can break up 20 *seers* (40 lbs.) of rough, and 20 *seers* of fine, bone-meal in 5¼ hours, and that the cost is 12 annas a maund (80 lbs.), against 14 annas when a modern bone-mill is used.

I also saw at work here a wrought-iron plough, costing Rs. 4½, introduced by Mr. Sen, and called the "Seebpore" plough. It worked well when properly used on land that was fairly soft, and inverted the soil, going 3 to 4 inches deep; but, if left to himself, the man working it would insist on digging the point of the share into the ground just as he would do with a native plough.

There was in a building on the Farm a good collection of implements of different kinds.

Sorgho (*Sorghum saccharatum*) is largely grown as a fodder-crop, and yields three cuttings in the year, a very good sale for it being obtainable in the town to people who keep cows.

The use of bones as a manure is extensively tried; but, so far, I could not gather that the results were at all conclusive. Bones cost in Calcutta Rs. 2 to Rs. 2½ per maund of 80 lbs.

The experiments are upon rice, jute, sugar, maize, barley, oats, wheat, and potatoes. They are almost entirely manurial experiments, but one is upon early and late ploughing for wheat, one upon the Mauritius system of cane-planting, and one upon new varieties of sugar-cane.

As at Dumraon, the greater part of the available area has been taken up and plotted out, leaving but little space for extension of experiments; also, too much ground has been given to manurial, and too little to cultivation, experiments, while there is no duplication of the manurial or unmanured plots, nor anything to test the suitability of the land for experimental trials.

The cultivation is better than at Dumraon, and the fields seemed more suitable in regard to situation. The Report, however, says that the results obtained at this Farm have, in many cases, been abnormal, the unmanured plots often yielding as much or more than the manured ones. In the absence of duplication of plots I am unable to say whether this is due to the soil or to other causes. Inasmuch, however, as the land previously was jungle land, it is probably too rich, more especially in vegetable matter, for any manures to exercise an influence, until by constant cropping it has lost some of its excess fertility. This is the reverse of what was found at the Saidapet Farm (Madras), and these two cases afford a useful proof of what I set out earlier, (*see* paragraphs 446 and 490), viz., that a soil may be either too rich or too poor for the land to serve as a suitable Experimental Farm. One thing is very certain, that it would well repay the time lost at the beginning were more care given to ascertaining beforehand whether a field was a suitable one for experimental purposes.

494. The Agricultural Department of Bengal has endeavoured to carry on experiments through a large number of *raiyats* and *zemindars.* In the account of these it is stated that, from the nature of the circumstances, it was not found possible to give accurate quantitative results. I have myself tried in vain to make out anything from the mass of confused, and often contradictory, results obtained, and I think that experimental work on such a scale as here attempted, and in the crude way employed, can do but little real good.

Experiments through *raiyats* and *zemindars.*

495. The foregoing account embraces the Farms which I actually visited when in India. The remaining ones that exist, but which I could not see, were those in Burma; these, I

Farms Province

believe, are devoted mostly to the growing and curing of tobacco. The attempt has been made to grow wheat also, but the people do not take to it, as rice grows so much better. In Berar there used to be a small experimental field, but it is now given up, so also is one that formerly existed at Ajmere.

In the Punjab, in Assam, and in Coorg, there have not been any Experimental Farms.

CONCLUSIONS.

496. CONCLUSIONS.

Experimental enquiry, conducted by means of special Experimental Farms, is a necessity in India for the development of agricultural improvement. It may be urged that the Farms which have already been in existence for some number of years have not been pronounced successes, and have fallen far short of what they were intended to accomplish; but, after visiting the Farms, and after reviewing the work done at them, I can only express my satisfaction at finding them so much better than I had been led to believe, and my surprise is great that so much has been accomplished with the imperfect and ever-changing machinery employed. The expense incurred for Experimental Farms, though perhaps rather large here and there, has, in my opinion, been by no means excessive, and the Farms compare very favourably in this respect with similar institutions in England and other countries.

What is chiefly needed now is, that there should be a better system of guidance in laying out the plans of experimental work at Farms, better supervision, continuity of enquiry, critical examination of results, and publication and dissemination of useful conclusions in a clear and intelligible form.

In accomplishing this, the association of a "scientific adviser" with the work of Experimental Farms will be invaluable.

Farms, omitting those directly connected with educational institutions, should be of two distinct kinds, (1) Experimental Farms, and (2) Demonstration Farms.

The work of Experimental Farms should be, mainly:—

(a) To institute comparisons between methods of cultivation practised locally and those in use elsewhere, which it may be considered desirable to introduce.

(b) To test upon different crops the effects of manures which are available, or which may probably be usefully applied in the future.

(c) To introduce new crops and new varieties of crops.

(d) To institute trials of new implements side by side with native or locally used ones.

(e) To improve the breeding of farm stock.

(f) To grow and distribute selected seed.

(g) To be Depôts for the locating of stud bulls.

Before any Experimental Farm is established, there should be a definite reason for its existence; there must be efficient supervision, a suitable situation and soil. A definite and well-devised plan of experiment should be drawn up, the outcome of the experiment having a distinct bearing upon the practice of the cultivating *raiyat.* There must be critical examination of the results, duplication and repetition of experiment, and, finally, publication and dissemination of the results, the issue of these in the vernacular not being omitted.

The success of Experimental Farms must not be gauged by their financial result, and they must not be expected to pay their expenses; but a sum of money ought to be laid out annually for their efficient carrying on.

Demonstration Farms should be established for the purpose of showing on a practical scale, and of bringing to the door of the cultivators, the results of what has been found on Experimental Farms to be an improved practice. Such Farms should be expected to pay for their cultivation expenses.

497. RECOMMENDATIONS.

RECOMMENDATIONS.

That agricultural enquiry be continued by means of Experimental Farms.

That distribution of selected seed and location of stud bulls be undertaken by Experimental Farms, as also the breeding of farm stock, where circumstances are favourable.

That Demonstration Farms be instituted in connection with Experimental Farms, in order to set out the results of successful enquiry.

CHAPTER XIX

AGRICULTURAL EDUCATION.

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AGRICULTURAL EDUCATION.

The influence of General Education.

498. It is not enough that improvements in agriculture should be effected by direct Government agency, and that measures, the result of enquiry and experiment, should be taken in the people's benefit, but it is necessary also that the people themselves should be brought to an intelligent understanding of what is being done, and that the endeavour be made to teach them how they may help themselves. This is the work of Education. In my second and third chapters I have shown how the spread of General Education will aid in removing many of those prejudices associated with "caste" and custom which render one class inferior to another in cultivating ability, and which frequently prevent the adoption of the more remunerative agricultural systems. This work, it was pointed out, will of necessity be a slow one, but it is a sure one, and its benefits have already begun to be felt. As regards the cultivating *raiyat*, there is very little doubt that, as primary education spreads in his direction, he will become more intelligent, less afraid of authority and officials, less disposed to regard them as opposed to his interests, more able and willing to set forth the grievances under which he suffers, while in his practice he will become more ready to receive new ideas.

The obligation to promote Agricultural Education.

499. It is not, however, with General Education, but with Agricultural Education particularly, that I am concerned. At the outset it must be borne in mind that, by the Government Resolution of 1889 on Technical Education, the Agricultural Departments have had put upon them specifically the duty of "taking positive measures for the education of the rural classes in the direction of agriculture" (*see* Chapter I., paragraph 6). As Sir Edward Buck most precisely laid down at the Simla Agricultural Conference, in October 1890, it is no longer a matter of *choice* whether Agricultural Departments will take up the subject of Agricultural Education or not, but it is a *positive duty* which they cannot evade unless released by the Secretary of State from the obligations put upon them. The importance of the subject was reflected in the prolonged and close attention which the Agricultural Conference at Simla gave to it, and in the several Resolutions which were passed upon that occasion.

My enquiry limited

500. For myself, without a knowledge of the languages, and a very limited one of the people, it was much harder to come to a definite conclusion upon matters connected with Education, more especially that which would meet the *raiyat's* wants, than to form an opinion upon what I could see with my own eyes, such as the practice of agriculture or the conduct of experiments. Agricultural Education, again, cannot be taken out of its connection with General Education, and I had neither the time nor the power to acquaint myself with the systems of general education as carried out in different parts of India. My observations upon the various grades of schools where I think that agriculture might enter as a part of the educational scheme may, therefore, not be assigned to their right divisions, or be only of partial and not of general applicability to India as a whole.

The tendency of education in the past.

501. There is very little doubt that the tendency of education in the past has been too much in a purely literary direction, and that it has been diverted from, rather than turned towards, the staple industry of the country, viz., agriculture. Agriculture is by far the most general pursuit, and it is that which contributes the bulk of the Revenue of the country. According to the Census Returns of 1881, 72 per cent. of the whole male population engaged in some specified occupation are directly supported by agriculture, and the estimate of the Famine Commissioners was that 90 per cent. of the rural population live, more or less, by the tillage of the soil. Nevertheless, it is found that the tendency of education at the present time is to draw the rising generation away from the land, and to give a purely literary training, which ends in a young man making his aim the obtaining of a post under Government, or the following of the profession of a "pleader" in the Courts. Agriculture is not regarded as a profession, but too often as a medium for deriving an income off the land; owners of land do not look after their property themselves, but leave it to the care of superintendents, and prefer to make money in the town by trading rather than by agriculture. So it comes about that estates worth a *lakh* of rupees (Rs. 1,00,000) are managed by men on a pay of Rs. 25 a month; there is no intelligent farming class, nor even a good class of superintendents; the young man, after receiving his education, seldom goes back to the farm, but soon sees that the best chance of utilising his education is at the Bar, or else in Government employ; the student at an Agricultural College will rather take a Government appointment worth Rs. 50 a month than devote himself to the management of his farm, or superintend that of some one else; and, lastly, there is a general impression that everything pays better and is more dignified than farming. As a well-to-do landed proprietor at Madura expressed it to me, "the "cleverest son is sent to the Law, the next into Government "employ, the dullest one goes to Agriculture or else to Trade."

The following extracts may be given in support:—

Sir E. Buck's opinion.

"The fault of our educational system is, that nothing in the scheme of "instruction sufficiently connects the knowledge to be acquired by the son "with the cultivation of the paternal acres." (Sir Edward Buck's Minute on Technical Education, 1886.)

Sir A. Mackenzie's opinion.

"There is need of something more than a purely literary curriculum . . . "our graduates . . . have schemes by the score for reforming the Empire, "but no idea of exploiting and developing its resources." (Sir A. Mackenzie's Minute on Technical Education, 1890.)

Mr. F. A. Nicholson's opinion.

"The education given has little or no connection with a lad's after-life. "There is nothing in it to teach him to farm, it does not teach him to "observe, or think about, or think new thoughts about, his processes and "products." (Mr. F. A. Nicholson on the Condition of Anantapur, 1887.)

The remedy and its benefits.

502. The present system of education is not sufficient to create and maintain that interest in the cultivation of the land which ought to be taken in an essentially agricultural country, and the only way to effect this is to substitute Agricultural Education for a part of the present educational programme. The advantages of such a course would soon be apparent, for, where so large a proportion of those who are to be educated are brought up amid rural surroundings, it must be simpler to bring before them objects which are familiar to them in their every-day life, than to instruct them in the literature and history of a foreign country totally different to their own. The benefit of a more technical course of education is, that it maintains the connection between the teaching which a lad receives and the calling which he is to follow in after-life; in no branch could this be more important in India than in agriculture. The teaching of the rudiments of science also is far more likely to lead to habits of observation, and of desire after enquiry, than a purely literary training. Even in the very simplest form of education the illustration of the lesson by means of the ordinary objects and operations of agriculture is the most ready help, and is more likely than anything else to awaken the interest of the scholar and to bring home the lesson to his comprehension. Object lessons can nowhere find more apt illustrations. Then as we go higher in the scale of education, the same subject is fertile in ideas familiar to the pupil, and then it is that an effort should be made to awaken his interest in the great industry, and to impart a knowledge of its principles which may be of use to him in his after-career. Nor need this interfere with the course of a lad's general education in reading, writing, &c.; it merely helps his comprehension by bringing before him familiar objects, and gives him, later on, the opportunity of utilising the knowledge of those elementary principles which he has learnt in his early days. When, as I have shown, the problem of agricultural improvement is so great a one, it becomes all the more necessary that early in life a sound teaching should be imparted in the elements of agriculture, so as to enable those whose lives will be largely spent in its pursuit to enter it with a fair understanding of its aims and guiding principles.

Progress must at first be slow.

503. The Agricultural Education of the masses, though it is what must be aimed at, can at first have no immediate effect. There are not merely the scholars at the different grades of schools to educate, but there are also the teachers, who will require systematic instruction before they can properly direct the training of their pupils. All this will require time to develop, but the sooner the work is begun the better. In addition, there are landed proprietors who require education in agriculture, there are the future "agricultural experts" to whom the work of enquiry is to be entrusted, and, lastly, there is the large class of subordinate officials of the Land Revenue Department, for whom an agricultural training is an undoubted *desideratum.*

The direction in which Agricultural Education should proceed.

504. The existence of different classes for whom Agricultural Education is to be provided in the near future points to the necessity of beginning the work, not from the lowest level alone, nor yet from the highest point alone, but from both simultaneously. Just as it would be unwise to neglect Agricultural Education of the higher type, and to provide merely for instruction of an elementary nature, without seeking to improve the standard in the future by the accession of men who have received a higher training, so would it be equally unwise to delay the commencement of the education of the masses until a fully competent teaching element had been provided, which might cause the stream of agricultural instruction to filter down from the upper to the lower classes. It seems to me that the best plan is, to make use of such resources as at present exist, and to seek to improve them by securing a succession of teachers who have received a high-class training, and have in their turn become fitted to be the instructors of other more elementary teachers. In short, I think that the work of high-class and of elementary instruction in agriculture should go on simultaneously, and that no system will be satisfactory which does not provide for both.

A University training such as can be provided at Colleges and special Institutions is requisite for the instruction of those who may be fitted to occupy the higher posts of the Revenue Service, or to enter the Agricultural Department as "experts;" so also for those who will become instructors at the High Schools and Agricultural Classes distributed throughout the country. Again, for those who will occupy subordinate posts in the Revenue Department, or who may qualify as teachers of lower schools, sound Agricultural Education of a more elementary nature will manifestly be called for also.

It is not, therefore, a question of whether education shall proceed from above downwards or from below upwards, but progress must be made in both directions simultaneously.

Special Agricultural Colleges not required.

505. Taking, for convenience' sake, the highest instruction first, we have to deal with such agricultural education as would be imparted at Colleges or special Institutions where agriculture forms one of the subjects taught, and where students prepare for a University degree or career. The Poona College of Science and the Saidapet College at Madras, are instances of such Colleges.

The question arises at once, whether agriculture in its different branches should be taught at special Agricultural Colleges, or whether it should merely form a part of the instruction at existing Colleges where a general training in science is provided. In its origin, Saidapet was representative of the former, as Poona is of the latter. After careful consideration, I express myself as not favourable to the establishment, at the present time, of special Institutions for the teaching of purely agricultural subjects alone, but I advocate rather the utilisation of existing Institutions where a training in science is given, and the tacking on of agriculture to the subjects taught. My reason for coming to this conclusion is, that in the present state of agricultural knowledge in India I much doubt whether there is adequate teaching power to provide instruction in the various branches of a complete agricultural course, and also whether, in a purely Agricultural College, there would be sufficient employment for teachers of ability in those departments of science alone which are connected with agriculture. The Madras Agricultural Committee (1890) reported that the results of agricultural education at the Saidapet College were disappointing, and that the sole object of most of the students joining the College was to obtain employment or promotion in Government service, very few indeed of them subsequently engaging in farming. The Poona College of Science, on the other hand, has only had agriculture as one of the many branches of science taught, and the results have, on the whole, been fairly successful. Within recent times the University of Bombay has given recognition to the study by conferring a Diploma in Agriculture on students who pass in that branch. The advantage which a general Science College, such as Poona, possesses, is, that it can employ capable teachers of botany, chemistry, geology, &c., who, while not engaged purely for agricultural students (as would be the case at an Agricultural College), nevertheless give courses which such students can attend, and other courses which are specially designed for them. I am, therefore, decidedly in favour of this latter system, for the present at least, as against the establishment of special Agricultural Colleges, feeling, as I do, that there is not sufficient call for the latter, and that adequate high-class instruction cannot as yet be provided in them. Looking to the future, it is possible that in time, perhaps, there will be occasion for one or more central Colleges of Agriculture, but there will always be a difficulty in finding a central place, more especially as the agriculture of different parts is so varied. For the present I prefer, as I have said, the utilisation of existing Science Colleges and Institutions, to the establishment of any fresh one specially for agricultural training.

Teaching of agriculture beneficial even if not followed for its own sake.

506. I have mentioned the recognition which the University of Bombay has given to the study of agriculture, and the testimony of men of long experience, such as Dr. Theodore Cooke, of Poona, is, invariably, that unless a teaching Institution be in some way connected with the University it is sure to fail. No doubt this is, in great measure, consequent upon what has been noted at Saidapet and elsewhere, viz., that the aim of the students is not to study agriculture for its own sake, but for the sake of getting Government employ or preferment. It is, of course, unfortunate that this is so, and especially that it is not merely a tendency but an almost universal rule. I do not think that there is much likelihood of a change, and therefore it is better to provide for things as we find them, and not as they might be. It will be long, I think, before we shall find, among the Natives, many workers in pure science who will study it for its own sake. So, too, will it be with agriculture. If a lower ideal has to be taken, it is nevertheless desirable to ensure, as far as possible, that the training shall be that which is most likely to be of benefit to the men in the spheres which they will subsequently

Instanced in case of Land Revenue officials.

occupy. It would unquestionably be well that the men who, later on, become Land Revenue officials, and who in their daily work are brought in contact with agricultural conditions and surroundings, should get some knowledge of the principles of agriculture during their earlier training. Even if they do make the attainment of a University degree the main object, and study agriculture in an academic way, it is more likely to be productive of good in the end than if they had followed a purely literary course. To take a single instance—in Bombay the higher class of Revenue officers, such as the *Tahsildars* and *Mamlatdars*, are invested with considerable influence in the distribution of advances for agricultural improvement (*taccavi** advances), and in the management of local funds. It is obvious that a man of this class who has had a good training in agriculture is very much more likely to use that influence wisely, and to understand the agricultural requirements of his district better than one who has had merely a literary training. Nor is the advantage confined to Revenue officials only, for it would tell favourably also upon those who did not go into Government employment; they would, at least, be fitted with a training which they could turn at any time to practical account, viz., in the business of agriculture itself, whereas a classical or literary education would not so qualify them.

I fear that one must not look for any great change in the aims of students at Colleges and Institutions; therefore, a greater endeavour should be made to render the Institutions of as practically useful a nature as possible. Seeing, too, the demand that there is for the employment of officers in the Revenue Department, and that they are brought into close contact with the cultivating classes, I consider that the call for the introduction of agriculture into the educational system has been amply justified.

Recognition of Agriculture by Universities.

507. The next point is, in what form a University may give recognition to the study of agriculture. At Bombay the efforts to obtain a Degree in Agriculture were not completely successful, and a Diploma was granted instead. But, undoubtedly, a diploma will never be considered as carrying the same weight as a degree, and this will certainly militate against the pursuit of agriculture as a study. A diploma is a sort of half-way house, better than nothing, but not the equal of a degree. I do not think that it is satisfactory, and I do not see why a University degree might not be given for Agriculture just as much, for instance, as for Engineering. I do not mean to imply that the improvement of Indian agriculture is in any way dependent upon the conferment by the Universities of an agricultural degree; but I do think that, seeing how matters stand, the granting of a degree would give a stimulus to the study of agriculture which a mere diploma would fail to produce. I do not suggest, I should explain, that agriculture should be studied as a subject by itself, and that a degree should be given in it without reference to the different branches of science connected with it, such as botany, chemistry, geology, and physics, but I propose that, after successfully qualifying in these branches

A degree desirable.

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* See footnote page 81.

by the earlier examinations, a student should be at liberty to take up agriculture as an optional subject in the final course for a degree.

The training at Colleges must be practical as well as theoretical.

508. Returning to Colleges, it is not sufficient to give merely a theoretical training in agriculture, but the instruction should be accompanied by practical illustration. This can be accomplished by having a *Demonstration Farm* attached to the College, where the students may see the actual operations of husbandry, and the cultivation of the different crops carried out. They should also be taught to do the work on the farm themselves, or have a piece of land which they can cultivate with their own hands. This may be sufficient for a College career or for a University degree, but more is needed before a man can be turned out from a College, and be fitted to manage a farm of any size or to superintend an estate. It is in respect of the opportunities which it offers of seeing practical work on a large scale that a Government Farm like Bhadgaon can be of great use, and it would be well to make it a condition that passed students of Poona or similar Colleges should not be promoted to the management of a farm or estate until they have spent some time in practical work on a farm like that at Bhadgaon. The complaints of landowners, that they cannot get competent superintendents, would in great measure be remedied by a provision of this kind, and it would prevent men from leaving the different Colleges with nothing but a theoretical knowledge of agriculture.

Agricultural Classes attached to High Schools.

509. Passing from Colleges to High Schools, we have to consider the Agricultural Classes which, in the absence of any special College, have been established in several parts of India, and which are, as a rule, attached to the High Schools. Those which I visited were at Nagpur, Belgaum, and Nadiad. With the first-named I was particularly pleased, and I am confident that it is doing decided good. It is quite true that here, as elsewhere, the prominent idea among the students is to get into Government employ, but it must also be remembered that in the Central Provinces there is a steady demand for men who are to be employed in the Land Revenue and Settlement Departments, and it is certainly far better that the appointments should be filled up by those who have had a distinctly agricultural training, and who have, possibly, acquired a decided interest in agriculture, than by men who have followed a purely literary career. The former are far more likely to understand the condition of the people, their wants, and the ways in which agricultural improvement may be effected. I was very much pleased to see that the students at Nagpur were obliged themselves to do the work of the farm attached to the Agricultural class, and that, in addition, each one had a piece of land which he cultivated entirely himself, and the crops of which he was allowed to convert to his own use. A *Demonstration Farm* is a natural and necessary adjunct of an Agricultural Class, and on it there should be practical work carried out by the students. If a certain area can also be devoted to experimental work it

Nagpur.

may be a further advantage, but all depends upon the superintendence available. Of 17 students in the Nagpur Class during 1889–90, 14 passed well and obtained appointments as Revenue Inspectors.

It is worthy of note, as showing the necessity of providing agricultural education of a high character, as well as that of an elementary nature, that the Nagpur Agricultural Class is dependent for its teaching power upon the Poona College of Science, the Principal and his two Assistants being passed students of that institution.

Nadiad.

At Nadiad the Agricultural Class is attached to the High School, agriculture being an optional subject in the school "final." The farm of the Nadiad Agricultural Association is utilised for the instruction of the Class.

Belgaum.

At Belgaum also, the Agricultural Class is attached to the High School, and a farm of seven acres is utilised for it. The teachers must have passed at the Poona College of Science. Agricultural Classes are likewise attached to nine of the principal High Schools in Bombay. Each of these is under an instructor who has qualified either at Poona or at Saidapet, and who reports to the Poona College. The examination papers are set from Poona College, and passed students are qualified to join the College.

Value of Poona College for supplying teachers.

The above instances show, if proof were needed, how necessary it is to maintain the agricultural teaching at the Poona College in a high state of efficiency.

High Schools.

510. At High Schools more attention should be paid to the study of physical science, and the instruction should also be made more distinctly agricultural in its bearing than is the case at present. Although there may not be the necessity which exists in the case of Agricultural Classes and Colleges, for having farms on which the scholars of High Schools may work, it is very desirable that there should be what I may best term *Illustration Farms*, on which the scholars may see the principal crops cultivated in the district, and have illustrated to them in this way the lessons which they are taught. Illustration Farms of this kind will help to bring home the instruction given and to give point and interest to it.

Illustration Farms.

Middle Schools.

511. In Middle Schools the elements of physical science should be taught, and it would be well, too, were more attention given to drawing. I noticed, when present at an examination at the Forest School, Dehra, a great lack of power on the part of the students to represent by means of a figure any object about which they were speaking. If drawing were more extensively taught at an earlier stage of their education it would be a considerable gain. Agricultural science might be introduced in Middle Schools by means of text-books in the vernacular, so also might elementary botany and physiology. There is no call for farms in connection with these schools, but there might be a few *Illustration Plots*, where some of the principal field crops could be grown on a small scale, just for the purpose of illus-

Drawing.

Illustration Plots.

trating the lessons. In the Central Provinces a scheme is on foot to establish School Gardens, on which the boys may work, and be allowed, as an encouragement, to keep the crop proceeds themselves.

School Gardens.

Primary Schools.

Agricultural "readers," and object lessons.

512. At Primary Schools the most that can well be done in order to further agricultural teaching is to introduce "readers," having familiar agricultural topics and illustrations as their subject, and also to give "object lessons." In the latter, nothing will be so quickly comprehended by the youthful mind as the common every-day objects which a lad sees around him, and none will be more familiar to him than those connected with agriculture. Sir Edward Buck remarked at the Simla Agricultural Conference that he had often watched the country visitors to the Indian Museum at Calcutta, and that there was no show-case that attracted so much attention as those which contained clay models illustrating the simple agricultural operations in a village. It is the familiarity of the subject which attracts, and so it will be found in primary education, for no illustrations are so apt as those drawn from the every-day life of those who come to receive instruction.

Normal Schools for teachers.

513. There remains but one other class of schools of which I shall speak, the Normal Schools for teachers. The teachers cannot all go through a special training in agriculture, seeing that agriculture is but one of several subjects which they will have to teach, but it is very desirable, and, indeed, necessary, that they should receive sufficient instruction in it themselves to be able to understand and to intelligently teach out of an agricultural text-book. To merely teach agricultural principles as a lesson to be committed to memory, but not to comprehend what the words mean, is utterly useless. Therefore, there should be some provision for the special instruction of teachers in agriculture, whereby they may obtain a sufficient knowledge of the subject to enable them to teach it to their scholars. At Nagpur, arrangements have been made for a special Class for teachers in connection with the Agricultural Class held there, and probably similar arrangements could be made elsewhere for the instruction of the teachers of Primary Schools. In some parts, the Central Provinces for example, peripatetic lecturers have been engaged to go from place to place, and to hold classes specially for this purpose, but the agency has, I believe, been found rather an expensive one. Whether this or some other plan, such as that adopted at Nagpur, of forming a special Class for teachers, be the better, depends much upon the facilities which already exist for giving instruction. It is significant, however, that in England (where at the present time a strong move is being made in the direction of technical agricultural education) the same necessity has been felt of educating the teachers of Village Schools in the rudiments of agriculture. It is recognised now, more or less generally, that, while agricultural education of a high class will be needed, there is not much to be expected so far as those now actually engaged in farming are concerned, but that it will be in the training of the young and rising generation of future farmers that the benefit of an agricultural education will be found. In India, as in England, attention must, therefore, be specially given to the training in agriculture of those who are to instruct the future generation of cultivators, and the teachers in Primary Schools ought to show their capability for doing this.

The need of Agricultural Text-books.

514. A manifest need is the issue of Agricultural Text-books and Agricultural Primers. A few of these do already exist. The best known is Mr. J. B. Fuller's "Agricultural Primer," originally written for the North-West Provinces, and subsequently re-written and adapted to the Central Provinces, upon Mr. Fuller's transference to the latter. This little book is simply and admirably written, and in its 100 small pages it contains a mass of useful information set out in quite an elementary way. The Primer has been translated into Hindi, Mahratti, and Uriya.

More recently, an agricultural Text-book, suited specially to Southern India, has been prepared by Mr. C. Benson, Assistant Director of Land Records and Agriculture, Madras, and Mr. C. Subba Row, the Sub-Assistant Director. One or two other Text-books or Primers have also been issued by native agriculturists.

But very much more is needed than a text-book here and there. The conditions of agriculture are so diversified that any such book, if it is to keep its elementary nature, can be applicable only to quite a limited area. As Mr. Fuller says in his preface,—when he came to revise his North-West Primer and to adapt it to the Central Provinces, he had to re-write fully two-thirds of it, and he adds that not *one* book for the whole of the Central Provinces, but at least one for *each* of its *divisions*, is needed. The same is true for any other Province of India, and thus there is urgent call for simple but reliable and applicable text-books upon agriculture. I look to the appointment of "agricultural experts" and the co-operation of a "scientific adviser" as likely to help greatly in this necessary and important work.

Language is a difficulty in the spread of education.

515. One of the difficulties in the way of spreading education is, undoubtedly, *language*, or rather the multiplicity of languages. I noticed this when I was at the Forest School at Dehra, during the holding of an examination there. In the higher Classes instruction is given in English, but the teaching is in the vernacular (Hindustani) for the lower Classes. The answers given by the pupils in the vernacular Classes were brought out with far more readiness than by the senior students, and it was often hard to make out whether the latter did not know the answers or whether they merely did not understand the questions.

It will be just the same with text-books. A text-book in English will not be understood like one in the vernacular, and it is far more likely to be learnt off as a lesson and committed to memory.

Even in one and the same Province several different languages and dialects will be spoken, and the text-book will have to be translated into each. At the present time there are in use in Colleges in India, books such as Wrightson's "Principles of Agricultural Practice," Warington's "Chemistry of the Farm," Johnston and Cameron's "Agricultural Chemistry and Geology," all of them capital books in their proper application, but not at all intended to meet the special case of Indian agriculture, and, indeed, even calculated to mislead the Indian student in many important points. Where the differences in agricultural practice between England and India are so great, dependence ought not to be put on English text-books only, but India should supply its own. That this has been done to so small an extent in the past is a proof of the need of paying more attention to the furthering of agricultural education.

Vernacular text-books.

Teaching of agricultural chemistry.

516. I have spoken in Chapter XVII. (paragraph 423) of the teaching of agricultural chemistry as a special subject, and have expressed my belief that, though useful as an adjunct, I do not anticipate any great results to follow immediately from it. Nevertheless, it is a subject which should quite rightly enter into a regular agricultural course, such as is given at Saidapet or at the Poona College, or into that of the Forest School at Dehra.

Relation of "scientific adviser" to agricultural education.

517. The relation of the proposed "scientific adviser" to the conduct of agricultural education throughout the country has also been spoken of in Chapter XVII. (paragraph 428), and was dwelt upon at considerable length by the Simla Agricultural Conference. I do not think that, if a "scientific adviser" be appointed, his connection with education can be anything more than of a very general nature. Certainly he can never exercise any *control* over education, or prescribe on what lines it is to run. The most he can do, it seems to me, is to generally watch its progress, and, possibly, to throw out suggestions for its improvement, but more he can hardly do, even had he time for it, which he most certainly would not have. Again, it would be inadvisable to have any conflict of authority between the Agricultural and the Educational Departments, and on this account, too, I think that the "scientific adviser" could do little more than express his opinion when asked, or make, as occasion permitted, some suggestion as to the line which agricultural education should take.

518. The question next arises : granted that there is a need of men more agriculturally trained, what inducements are to be given to them to pursue the study of agriculture? If young men go to other employments because there are no openings for them in agriculture, how are these openings to be made? Only by giving as good "prizes" for agriculture as for the Bar or for Government employ. The Land Revenue Administration needs a regular supply of men to fill posts in it; Land Revenue Inspectors are required whose business is with the people in their agricultural relations, and who have to do with the soil and the crops. Surely those best fitted are the ones who have had an agricultural training, and the administration of matters concerned with the land will be best carried out by the men who understand agriculture best. In England a land steward is not a man who is taken out of a bank, or who has done no more than take a high University degree in classics or mathematics. So should it be with Land Revenue Inspectors; they should be men who have passed through the Agricultural Classes, or through Institutions that give a training in agriculture. In the course of my tour I met many Inspectors whose mind seemed to be quite a blank on the subject of agriculture; in other parts, as in some districts of the Central Provinces, I found them to take a decided interest in agriculture. These latter were men who had passed through Mr. Fuller's Agricultural Class. In Bombay it is now provided that all candidates for the staff of Inspectors of Village Records must qualify by passing a course in agriculture.

I cannot put these views into better general terms than those adopted in the following two Resolutions adopted at the Simla Agricultural Conference, in October 1890.

> Resolution VI.—It is highly desirable that the claims of men trained in Scientific Agriculture to appointments in the Revenue and cognate Departments should be as freely recognised as those of men trained in Law, Arts, and Engineering.
>
> Resolution VII.—That where appointments in the Revenue or cognate Departments are made on the result of competitive examinations, Scientific Agriculture should be included as an optional or necessary subject in the examination course.

Forest students.

The Forest Department has for some time past felt the necessity of having better-educated men to occupy the post of Sub-Assistant Conservator. Efforts are now being made to effect an improvement in this direction, and the introduction of a more agricultural education among these men would qualify them better for their work.

Patwaris.

Lastly, as regards the hereditary class of keepers of Village Records (*patwaris*), it would be a clear advantage if these men, whose office passes on, as a rule, from father to son, were in their early life to receive a training in the principles of agriculture, and also in drawing, instead of having, as is now the case, to be formed into special Classes later on in order to learn their particular work.

Classes of Natives for whom agricultural education is needed

519. It may be desirable here to summarise the different classes of Natives for whom agricultural education should be specially provided.

(1.) "Experts" of the Agricultural Department.
(2.) Subordinate officials of the Land Revenue, Settlement, Forest, or cognate Departments.
(3.) Teachers of agriculture at High Schools.
(4.) Teachers of Middle and Primary Schools where the elements of agriculture are taught.
(5.) The youth of the cultivating classes.
(6.) Non-official landed proprietors (*zemindars*, &c.).

Agricultural Colleges and Classes.

Poona College of Science.

520. It now remains for me to note briefly upon the Agricultural College, Classes, and other Institutions which I visited. To take, first, the Poona College of Science, so far as its agricultural course is concerned.

This college in its agricultural branch is virtually the Agricultural College of the Presidency, and those who have had anything to do with it know how greatly its success has been the outcome of the devotion of its energetic Principal, Dr. Theodore Cooke. Successive Governors of Bombay, and more especially Lord Reay, have also interested themselves greatly in it. I have already made numerous references to it, and have shown what a large amount of the agricultural teaching already given throughout the country owes its origin to Poona. The College has the advantage of being affiliated to the Bombay University, the latter giving a diploma in agriculture. The students have the further benefit of the farm attached to the College, and are lodged close to the farm, spending some time on it every day. The course is a three years' one. Mr. Mollison, the Superintendent of Government Farms in Bombay, teaches agriculture for two months in the year here. In the first year mathematics and natural science (heat, botany, and agriculture) are taken up; in the second year, higher mathematics, natural science (chemistry and systematic botany), veterinary science, and agriculture; in the third year, natural science (agricultural botany, geology, and chemistry with analysis), surveying, veterinary science, and agriculture.

The main points that strike me in this scheme are, firstly, that I think it would be better to let students qualify in general science subjects before passing on to the more special one of agriculture; and, secondly, that I would not hamper an agricultural student's progress by keeping him at a non-agricultural subject like mathematics for a second year. It is quite right that a man should reach a sufficient qualification in mathematics and physics, but I would let him get this done in the first year of the course, and not to be troubled with it further. Also, it is well that he should attain a sufficiently high standard in general science subjects, such as chemistry, botany, and geology, before he enters on the special study of agriculture. Agriculture might be taken the second year, and be made the principal subject during the third year, when, too, it would be quite early enough to take up veterinary work.

What I should suggest would be:—

First Year's Course.

Mathematics.
Physics.
Elementary Chemistry.
Elementary Botany.
Elementary Geology.

Second Year's Course.

Chemistry (Theoretical and Practical).
Biology.
Drawing.
Agriculture.

Third Year's Course.

Agricultural Chemistry.
Agriculture.
Surveying.
Veterinary Science.

In looking over the syllabus in agriculture, it is clear to me that it has been drawn on an English and not on an Indian model. Thus, practices such as "paring and burning" and "warping of land" are mentioned; manures such as sulphate of ammonia, dried blood, soot, and artificial manures, none of which have any place in Indian agriculture, are introduced; the requirements of "fattening animals" are supposed to be learnt, and this in a country where no fattening of animals whatever is carried on. On the other hand, many subjects which have a special interest in Indian agriculture are omitted, such as canal and well irrigation, *kankar*, oil-cake refuse, *ghi*, &c.

The principal requisite for the Poona course is, to my mind, to make provision that the students have more acquaintance with the practical side of agriculture, either by themselves working upon the farm, or by having a portion of land which they may cultivate themselves, or else by spending a certain time upon the large farm at Bhadgaon. Certainly, too, before men pass out from Poona to take charge of estates, they ought to have previously qualified by a residence at the Bhadgaon or similar farm.

Veterinary hospital.

Bacteriological laboratory.

Attached to the Poona College is a Veterinary Hospital, where animals are treated and Classes are held. Still later, an important branch has been added by the Government of India, a Bacteriological Laboratory having been started and put under the management of Dr. Lingard, with the view, principally, of studying the important matter of cattle diseases in India.

Baroda College.

521. At Baroda great advances have been made lately in the development of agricultural education, and the Gaekwar has shown great interest in the subject.

An agricultural branch of the Baroda College has been formed, and is affiliated to the University of Bombay for the diploma in agriculture. Mr. T. H. Middleton, who passed a distinguished career as a student at Edinburgh University and elsewhere, has been appointed Professor of Agriculture, and Demonstration Farms have been started under his guidance. The students are to reside on the farms. This College and the Poona College of Science, will constitute the two Agricultural Colleges of the Presidency.

522. The other Bombay Agricultural Institutions which I visited were the farms, or rather fields, in connection with the Agricultural Classes attached to the High Schools at Belgaum and Nadiad. As mentioned a little before, there are Agricultural Classes attached to nine of the High Schools in Bombay.

Belgaum.

At Belgaum, bursaries of Rs. 4 per month are paid out of the local funds, and are tenable for three years. The field is seven acres in extent, and the out-of-pocket cost is Rs. 240 a year, which the Municipality gives as a grant. Theoretical instruction is given in the High School to the better and English-speaking classes, while, for the others, text-books in Mahratti are provided : the lads work three hours a day on the farm. The teachers must have passed at the Poona College.

Nadiad.

At Nadiad the farm of the Agricultural Association is thrown open to the students attending the Agricultural Class of the High School. A museum, with specimens of crop products, implements, &c., is attached.

523. Passing next to Madras, the Saidapet College calls for special attention. Its history has been dealt with in the last chapter (*see* paragraph 488), and now I have only to remark on what I noticed when I visited the College and Farm.

Saidapet College.

Of the unsuitableness of the Saidapet Farm, either as an experimental or even as an educational farm, I have already spoken, and, after having seen it, I am not inclined to regard at all favourably its proposed extension, even as a farm for teaching purposes.

Owing to the constant change of policy pursued by the Madras Government with respect to the College and Farm, these have laboured under considerable difficulties ; and although the Farm had, at the time of my visit, been given up, with the exception of a small area, the future of the College was in a very unsettled state. Originally started as a purely Agricultural College, Saidapet has now become little more than a general Science College for Madras, at which agriculture merely forms one of a number of subjects taught. This is abundantly clear from a perusal of the syllabus adopted. The agricultural course contains far too many subjects, and, to all appearance, far too great attainment in these is expected. Mathematics (including trigonometry and logarithms), mensuration, statics, building-materials and construction, physiography, forestry, and other subjects find a place, along with agriculture, agricultural chemistry, and veterinary science. If properly carried out, the syllabus would involve each man being turned out a master of the particular branch taken up ; the veterinary programme, for instance, ought to make a man a qualified veterinary surgeon; the qualifications demanded in statics would only be attainable by a very few, and it would be far better to confine this branch to elementary mechanics, with special application to machines used in agriculture; the syllabus in agriculture is largely occupied with subjects that come more properly within the domain of agricultural chemistry. The general conclusion forced on me was, that a syllabus had been framed with the intention of comprising all the points about which knowledge had been obtained by men of science all over the world, and that the teaching was expected to embrace all these as far as possible. In short, an ideal syllabus was set, and the teaching had to be *worked up to* it, instead of the syllabus being set according to the standard of the teaching, and to what might fairly be expected of the students The result of such a treatment must be to make the men rely entirely on books, and upon getting them up by heart. So I was not surprised to hear that the students did no practical work upon the farm, or that they turned out in most cases inefficient superintendents of farms when they left the College.

A syllabus should not be framed so as to be far above the heads of the pupils, and appal them with the array of all that they have to get up for it, but it should be set so as to be an index of the requirements which the education given could fairly supply.

The main point to determine with regard to the Saidapet College is, I think, what its future is to be. Is it to be an Agricultural College? If so, the course ought to be a more purely agricultural one, with superfluous subjects struck out, and practical work substituted for them. If, however, it is to be a general Science College, then let this be clearly understood, and let agriculture merely take its place as one of the subjects taught.

524 The Central Provinces do not possess any Agricultural College, or even Science College where agriculture is made a special part of the instruction. The nearest approach to this is the Agricultural Class at Nagpur, of which I have already spoken favourably.

Nagpur Agricultural Class.

At the time of my visit there were 38 students, 10 of whom were boarders, and most of them Brahmans. The principal object of the students is here, as elsewhere, to get Government employment, but in these Provinces there is a decided want of men to fill subordinate posts in the Land Revenue and Settlement Departments. In the previous year 14 of the 17 passed students of the Class had obtained positions as Land Revenue Inspectors.

A prominent feature in the training is, that the students are obliged themselves to engage in manual labour on a farm of 20 acres attached to the Class. The Nagpur Experimental Farm is also available for the instruction of the Class, and, in addition, each student has half an acre of land which he cultivates himself, and the crops off which he is allowed to have. Unfortunately, owing to the difficulty of getting men and labour just when they are wanted, this cultivation is somewhat hindered, but the students take a decided interest in it.

A certain number of the scholarships of the Educational Department are tenable at the Agricultural Class, the course extending over two years. The teaching agency is entirely supplied from the Poona College of Science.

I thought the arrangement of subjects taught, and also the syllabus, very satisfactory indeed; there were no superfluous subjects, and all of them had a direct bearing upon the principal subject, agriculture. They comprised agriculture, elementary chemistry, botany, geology, elementary veterinary science, land surveying, and drawing. Thus, it will be noticed, the students did not have their time taken up with non-agricultural subjects. At the end of each week a written examination is held, and, as the instruction is given in English, it is found that the plan of having the weekly examinations is very useful in familiarising the students with expressing themselves clearly in English. There are small laboratories and a museum and library. All that there was was excellent of its kind, though on a very limited scale. The Class at Nagpur illustrates the difficulty which language presents to the spread of agricultural education. So far, teaching has been given only in English and with English text-books, but arrangements are being made to have a vernacular Class also.

525. Bengal possesses no Agricultural Colleges, or educational Institutions where agriculture is specially taught. Instead of this, it had been at one time the practice to send selected Natives to England to study agriculture at the Cirencester College. This has, however, now been abandoned. In place of it, it is proposed to have an agricultural branch at the Seebpore College of Engineering, near Calcutta, and to utilise the Seebpore Experimental Farm which adjoins the College. Bengal.

In the North-West Provinces there is no Agricultural College, nor special provision for the teaching of agriculture. North-West Provinces.

In the Punjab the only step in an agricultural direction has been the establishment of a Veterinary School at Lahore. This was started in 1882, and has been decidedly successful. Punjab. Veterinary College, Lahore.

526. The last institution that I need mention is the Forest School at Dehra. Forest School, Dehra.

This, though not a College for imparting instruction in agriculture, has, in some ways, nevertheless, an agricultural bearing.

There are courses for Foresters (conducted in Hindi), for Rangers (in English), and for the highest grade, that of Sub-Assistant Conservators. The number of students is about 70, and the expenditure, which amounts to about Rs. 33,000 yearly, is debited to the various Provinces who send up students to be trained. Every year some twenty men qualify as Rangers, and, after five years' service, they are eligible for Sub-Assistant Conservatorships as vacancies occur. It is almost unnecessary to say that out-door instruction forms an important part of the course. The scheme of instruction drawn up appeared to me to be an excellent one, and the teaching, in the main, to be very well given. For instruction in chemistry, botany, and entomology, the school depended until lately upon lectures given during a few weeks by non-resident lecturers. There is, however, a very suitable chemical laboratory at the school, and, as explained in an earlier chapter, it is hoped to provide shortly for regular instruction in agricultural chemistry.

I happened to be at Dehra when the sessional examinations were going on, and was allowed the opportunity of putting several of the students through *vivâ voce* examinations in botany and chemistry. I can speak in high terms of the degree of proficiency attained by the students in the former subject. The students whom I examined were especially well acquainted with vegetable morphology, and had evidently received a very careful training. Their knowledge of chemistry was, however, poor. The groundwork of the science had not been thoroughly taught them, and while they could answer some of the more advanced questions, simpler ones, such as the definitions of an acid, an alkali, and a salt, were not known. I was chiefly struck by the fact that the teaching in chemistry did not seem to have been directed to those points which would be most useful to the men as forest officials. For instance, I do not remember that any one could give me a clear idea of the composition of leaves, or of the different forms of combination in which carbon exists in vegetation.

In listening to the examinations in other subjects I was struck by the inability of the students to draw any figures by which they might illustrate their answers ; also by the need that existed for more out door examination ; the students did not seem able to describe clearly such operations as that of digging a well, making a road, bridging a channel (*nullah*), blasting a rock, &c. Undoubtedly they experienced some difficulty in expressing themselves in English, and seemed to be always trying to remember something out of a text-book.

There were what seemed to me marked defects about the examination itself, though I believe that these have to some extent been since remedied. Thus, the examinations ought not to be conducted (as they used to be) by the teachers of the school alone; a student, after failing once, should not be allowed to go in for a special examination a short time afterwards and try to pass then; and, thirdly, far too much time was taken up by the examinations. The one that I was present at for a time was fixed to last from March 5th to March 29th, and was entirely of a *vivâ voce* nature. During its progress all the work of teaching was disorganised and, in fact, suspended except in one Class. I sat out the third day of the examination in forest engineering, itself a subsidiary subject, and I felt that it was quite impossible for any examiner to keep up his interest all this time. Half-an-hour's *vivâ voce* examination is more than enough to ascertain a man's real knowledge of a subject, and I should like to see this supplemented by written periodical examinations. These are points which can readily be remedied, and it is but right that I should say I thought very well of the teaching as a whole. There is a demand for a better class of men to fill the post of Sub-Assistant Conservator, and it is very desirable to maintain the instruction at the Forest School in a high state of excellence, so that the men sent out may have a more intelligent view of their duties. The introduction of a more agricultural element, even if by the teaching of agricultural chemistry alone, is likely to give the students a better idea of the important connection of their work with the improvement of agriculture.

CONCLUSIONS.

527. CONCLUSIONS.

The spread of education will be an important element in the improvement of agriculture. It will do much to remove the prejudices attaching to "caste" and custom, which prevent progress in agricultural methods, and it will give rise to a more intelligent farming class.

In a country where, as in India, agriculture is the chief employment, Agricultural Education especially should be encouraged. Until lately the tendency of education has been in a purely literary direction, and has turned attention away from the land rather than towards it; the fault can now be best remedied by substituting Agricultural Education for a part of the present educational programme. The work must proceed simultaneously from above downwards and from below upwards. Elementary instruction should be given in Primary Schools by means of "readers" and "object lessons" which introduce familiar agricultural subjects. In Middle Schools the elements of physical science, the use of Agricultural Primers, accompanied by *Illustration Plots* on which the ordinary farm crops are grown, should form part of the instruction. In High Schools more attention should be given to physical science and to agriculture, and *Illus-*

tration Farms or fields should be attached to the Schools. Agricultural Classes should be established where Colleges or Institutions that specially teach agriculture do not exist, and these should have *Demonstration Farms* attached, and land on which the pupils can themselves work.

Special attention should be directed to the agricultural education given in Colleges, in order that the teachers supplied to High Schools and to Agricultural Classes may be well-trained men, and that the Land Revenue, Agricultural, and cognate Departments may be supplied with subordinate officials who have studied agriculture, both theoretically and practically.

I do not consider it advisable to establish special Agricultural Colleges, but I think that it would be better to utilise existing Colleges of Science and to form agricultural branches at them. Universities should encourage the study of agriculture by making agriculture an optional subject in the course for a degree, and the claims of men who have passed in agriculture should be fully recognised for appointments in the Revenue and cognate Departments.

There is great need of Agricultural Text-books suited to the circumstances of the different parts of India, and these should be in the vernacular as well as in English.

528. RECOMMENDATIONS.

RECOMMENDATIONS.

That General Education be extended among the agricultural classes.

That Agricultural Education form a part of the general educational system, and be introduced as a prominent subject in the Schools of the country.

That Text-books on Agriculture, adapted to the different parts of the country, be prepared as early as possible.

That encouragement be given to the higher study of Agriculture by recognising more fully the claims of men who have passed in scientific agriculture, for appointments in the Land Revenue and cognate Departments.

CHAPTER XX.

AGRICULTURAL DEPARTMENTS.

Scope of this chapter.

CHAPTER XX.

AGRICULTURAL DEPARTMENTS.

529. THE previous chapters have of necessity been concerned largely with the work of Agricultural Departments, considered under the different heads selected for those chapters. There remain, however, some few matters which may be usefully discussed, but which do not come specifically under any of the foregoing heads. These I shall treat of in this concluding chapter.

The training of junior Civilians in agriculture.

530. The origin, development, and general history of Agricultural Departments in India have been narrated in Chapter I., as well as their scope and aims. But their constitution has not been fully dealt with.

One of the most important matters, to my mind, and one to which, it seems to me, far too little attention has been given in the past, is the early training of the men who are to form the *personnel* of Agricultural Departments, and more especially of those who may in future be appointed Directors of Agricultural Departments.

Recommendations of Famine Commissioners, 1880.

The necessity of guiding in a more scientific and more agricultural direction the training of Indian Civil Servants who may, later on, occupy posts in Agricultural Departments, impressed itself strongly upon the Famine Commissioners in 1880, and has also been made the subject of representations by successive Secretaries of State. The Famine Commissioners laid considerable stress upon the training of junior Civilians in agriculture, and they recommended—

(1.) That more weight should be given to natural and physical sciences in the open competitive examination.

(2.) That agricultural and organic chemistry should replace some of the compulsory subjects in the intermediate and final examinations of probationers for the Civil Service.

(3.) That candidates who distinguish themselves in these subjects should, further, be allowed to spend an additional year in England for the purpose of studying agriculture; the time to count as service on two-thirds pay.

(4.) That these selected officers, after a period of service in the ordinary line in India, should be enlisted in the Agricultural Departments.

(5.) That, in the meantime, a few selected junior Civilians should be sent to England, after five years' service, to study for a year or more at some School of Agriculture.

The Government of India's views.

Although these proposals had a great deal to recommend them, there were obvious defects which the Government of India, with, I think, much justice, pointed out in their reply. It was urged that a knowledge of agriculture could only be of special value to a few in the Civil Service; that a Civilian must first be fitted for ordinary executive and administrative functions, and that his probationary training in England should be framed with this view. It was impossible that a man could get more than a theoretical or book knowledge of agriculture by the time that he passed his final examination, and what knowledge he could get would not be applicable to the peculiar conditions of Indian agriculture. So the Government of India objected to giving any agricultural training to Civilians previous to their arrival in India, but they favoured any measures to arouse interest in the subject of agriculture, and consequently endorsed Mr. Ilbert's recommendation to admit agricultural chemistry as an optional subject of the final examination, along with botany, geology, and zoology. The Government of India further proposed to give definite privileges to officers selected in India, to induce them to undergo an agricultural training in India, viz., by allowing men selected by Local Governments to take furlough after five years' active service (instead of the usual eight years), and by authorising Local Governments to select one officer every two years to go on furlough to England to study agriculture. Lastly, they considered that every Revenue officer should have a rudimentary knowledge of Surveying, as practised in India for the purposes of Land Settlements.

Secretary of State's decision, December 1883.

To these proposals the Secretary of State gave, in December 1883, a general approval. He allowed agricultural chemistry to be an optional subject in the final examination. But he objected to the withdrawal of officers from their duties in India, and declined to lay down any general rule, though consenting to act, in special cases, in the spirit of the above proposals when Local Governments submitted special recommendations.

Agricultural chemistry a subject of the final examination.

As the outcome, agricultural chemistry became, and now forms an optional subject in the final examination, and a limited number of Civilians have been sent home to study agriculture at the Cirencester College; also, something has been done to provide instruction in Surveying to Revenue officers.

My conclusions.

531. With what has been done I can, in the main, agree. I do not think it is possible to send out Civil Servants who shall be practical agriculturists also; I recognise (as I have expressed myself in Chapter XVI., paragraph 408) that the Service demands other requirements in its members than that of being agriculturists, and that a man must learn primarily to be an executive and administrative officer. I do not think, therefore, that practical agriculture can usefully be included in a probationer's examination. I can, further, see that there are objections to keeping a man in England a year longer for the purpose of studying agriculture; and, besides the fact that the time is too short, and that Indian agriculture is very different from English, there is the

Necessity of giving more weight to the study of Natural Science.

consideration that a man would, by so doing, get out of the regular line, and thus raise difficulties as to promotion, time of service, pay, &c. But I do endorse most thoroughly those recommendations of the Famine Commissioners, and of the Government of India, which have for their object the giving of more weight to the study of Natural Science. I maintain that what is needed is not so much to have men, or I will say Agricultural Directors especially, who shall be practical agriculturists, but to have men of a scientific turn of mind, who have some knowledge of what science has accomplished in the past, and of what it is likely to effect in the future; men who will have some appreciation of scientific work and of workers in science. Now, this can only be gained by an early training in scientific subjects, and, although the details of agricultural practice can be acquired at a later date, the pursuit of scientific methods and their application to practice cannot. I have been much struck in India by the almost complete isolation in ideas of the few men who have gone out to the country possessed of some knowledge and appreciation of natural science. They have, as it were, stood almost alone, unappreciated, or, rather, not understood, by their more classical or mathematical brethren. Yet I can see quite well that, among the men who have done most to help on agriculture, in many cases the impulse has been given by their love and appreciation of natural science. I think that the tendency of modern education to proceed in the direction of a more liberal and scientific training will carry with it important results which will indirectly influence even Indian agriculture, and that, with the coming of more Civilians to India who have had a certain amount of training in natural science, a class of men will be obtained whose presence will aid the improvement of agriculture by making the application of scientific methods more easy, and better appreciated.

I think, accordingly, that the giving of more prominence to scientific subjects, both at the open competition and at the later examinations for the Civil Service, would be attended with decided benefit, and that from the men who have distinguished themselves in this branch some might be selected who would subsequently prove useful officers in the Agricultural Department.

Agricultural chemistry at the final examination.

532. As to agricultural chemistry, now an optional subject at the final examination, although I am, as an examiner myself, obliged to allow that many candidates take up the subject purely with the view of swelling the total of the marks that may stand opposite their names, I have every year, so far, found some few men who have shown more than a passing interest in it, and who, if opportunity were given them of subsequently turning their attention in an agricultural direction, would, undoubtedly, be able to derive and to impart benefit from their study of agricultural chemical principles. It is men such as these who should be noted when they have done well, and it is from them that the future Agricultural Directors might advantageously be selected.

Employment of junior Civilians in Department of Land Records and Agriculture.

533. But it is not enough to merely note such men; it is necessary, too, that they should, on arrival in India, be brought into contact with agriculture and its conditions, and be encouraged to study it in its varied relations.

It is universally acknowledged that a young man on his first coming out to India is, to put it broadly, of very little use. He cannot be entrusted with any post until he has got to know something of the language, the people, and the district where he is. As a Collector of experience told me, "the best thing is to "send the new comers out into the fields for four months or so, "and then they may begin to pick up something." If, on the other hand, they are left to gather their experience in the court-house (*cutcherry*) they soon lose the little agricultural knowledge they had, and never get to understand thoroughly the conditions of the people and of their agriculture.

Departmental examinations in agriculture.

It would be well, therefore, that when men come fresh to the country a certain proportion should be drafted into the Department of Land Records and Agriculture, and in this way come to know, at the opening of their career, something about the country, the people, the crops, the system of Revenue Administration, and the agricultural conditions generally. How, I might well ask, is a man to be expected to understand the important issues involved in the establishment of "Fuel and Fodder Reserves," if he has not had some insight into the circumstances which call for their creation? At the same time, these junior Civilians might be instructed in the principles of Land Surveying. At the departmental examinations, after arriving in India, men are examined upon the local tenure system, and upon the law of the district where they happen to be fixed; but why should they not be examined upon the local agriculture also? I think that this would be one of the best ways of picking out the men who showed an interest in agriculture, and who gave promise of being able to deal well with it. If Agricultural Directors were selected from men who had undergone some training of this kind, instead of being chosen (as at present) without any or with very little regard to their agricultural knowledge or powers, it would be very much better for agriculture.

Encouragement to study agriculture when upon furlough.

It would also be a useful stimulus to these men if encouragement were given them to study agriculture in other countries when absent upon furlough.

The position of Directors of Agricultural Departments.

534. It is not only in the method of selecting Directors of Agricultural Departments that a better system should prevail, but it appears to me that there should be some alteration as regards the position which a Director occupies, and chiefly in his relation to the existing Revenue Administration. At present the description I have heard applied to the Director, that of being a "fifth wheel of the coach," is very near the truth. He has no administrative powers, and can only act as an adviser; he has not even the power of fining or of dismissing an Inspector who does not see properly to the keeping up of the Land Records in his district, but he must refer the matter to the Revenue authority. His title, "Director of the Department of Land Records and Agriculture," as I have remarked before, is a most cumbrous one, and in some Provinces the first portion of it only is retained, to the exclusion of agriculture. It is very certain that in different Provinces different circumstances will prevail, and hence it may not be possible, and indeed would not be wise, to give the Director of the Department of Land Records and Agriculture the same position everywhere alike. Nor can his duties be everywhere the same. He must, in brief, be made to fit into the existing Revenue organisation in each Province, and be put where he will go best. He should form a part of the Revenue Administration, and not have his duties confined merely to the giving of advice. As I pointed out earlier (Chapter VI., paragraph 113), he should have a large share in the management of *taccavi* advances for the purpose of digging wells, &c., even if the actual control and disbursement cannot be left in his hands. Again, he should have the power of making representations as to the giving, in special cases, of exemption from assessment, and of reporting upon instances of over-assessment. As regards other Revenue officials, a Director ought to stand higher than he does at present. The post is one that should be occupied by a moderately senior man, ranking with the highest grade of Collector, but a little below a Commissioner. I would much prefer to see the title "Commissioner of Agriculture" given to him instead of the present one, as the title would more adequately describe his duties and define his position.

Commissioner of Agriculture.

The need of touring.

535. The desirability of an Agricultural Director's spending a considerable time each year in touring should be self-evident, and yet there are Provinces in India where the Director does not go on tour at all, or where very little touring is done. To get by personal enquiry and observation a knowledge of the agricultural requirements of a district, whether as regards water supply, wood supply, cattle, seed, or the incidence of assessment, is of the very nature of a Director's duties, and how he is to discharge these properly without going about in the districts of his Province I fail to see. If this part of the work be given up, it is little to be wondered at that the Director will leave out agriculture from his title, and confine himself to Land Records.

The Secretary of the Imperial Agricultural Department.

536. The above remark applies in a special manner to the Secretary of the Imperial Agricultural Department. With numerous duties and a variety of subjects to deal with, on *all* of which he cannot be an *authority*, the Secretary of the Department must rely upon others. It is well, therefore, that he should be brought from time to time into touch with the officers of the Provincial Departments. There will frequently arise matters which call for personal inspection, or, it may be, for personal explanation, and the experience of a Secretary who has knowledge of what has been done in other Provinces may often be of much use in guiding the counsels of Provincial Departments. Without unduly forcing upon a Provincial Department any particular line of action in individual cases, it is well that there should be uniformity of purpose, and the same guiding principles, alike in Provincial and in Imperial Agricultural Departments. An occasional meeting of the chief officials would be beneficial in securing harmony of action and the promotion of common interest. In this respect I would like to see, combined with the office of Secretary, duties which are more akin to those which would fall to the lot of an Inspector General.

The value of Conferences.

While on this subject, I might add a word expressive of my belief in the usefulness of occasional Conferences, for the purpose of exchanging views on agricultural questions, and of bringing into closer harmony the work of Imperial and of Provincial Agricultural Departments. My own experience of the Conference held at Simla, in October 1890, impressed this very clearly upon me, and I have to acknowledge much benefit and information which I derived from the interchange of views by representatives coming from different parts of the country, who in this way brought their experience to bear upon the particular points set for consideration.

Classification of the work of Agricultural Departments.

537. The general work of Agricultural Departments may be described by giving the different headings under which the Government of India has prescribed that the Reports of the Operations of the Departments should be made.

These are as follows:—

I. Organisation and Maintenance of Village Records.
II. Analysis of Districts with reference to security from Famine.
III. System of Collection of Revenue and Rental in precarious Tracts.
IV. Measures of Protection against Famine.
V. Agricultural Experiments, including Farms.
VI. Cattle-breeding and Veterinary Establishments.
VII. Agricultural and Fiscal Statistics.
VIII. Trade and Trade Statistics.
IX. Museums, &c.
X. General.

Most of these subjects have already been dealt with in this Report, while others, such as Statistical Records, are not connected with my special work. It will but be necessary to touch upon a few general points not already noticed, and to mention special features of the work of individual Provincial Departments.

Village Records.

538. I frequently had the opportunity of inspecting Village Records, and of watching the work of the Village Accountants (*patwaris*), District Inspectors, &c., as also the maps relating to Settlement operations. It was very clear to me that a great deal of care had been given to the perfecting of the work of Land Records, and to the training of the men to whom the keeping up of these is entrusted.

They need to be collected and digested.

The one matter in which there seemed to me to be a lack was, that the statistics obtained, say, for individual fields or holdings, need to be collected together and to be then digested. The main points brought out by the *figures* require translation into *words*, so that useful general conclusions may be drawn from them. Thus, it is not enough to merely record that irrigation has decreased over a certain area, or that a less acreage is occupied by a particular crop. One wants to know the *reasons* for these changes. Then, there are apparent discrepancies which need explanation, and general results ought to be collected for each district. The real requisite is, it seems to me, a central Bureau of Agriculture, where the returns would be gathered together, examined, digested, and put in a handy form for general use. Something similar to the useful work done by Mr. J. E. O'Conor for the Trade of India should be instituted in connection with its Agriculture.

In Bengal, in consequence of the existence of a permanent settlement, there are no Village Records, except those relating to Government and private Estates. These Estates cover altogether about 20,000 square miles. There is, consequently, no regular *patwari* staff. When speaking of indigo cultivation in Behar I mentioned the difficulties which arise in consequence of there being no Record of Rights; from what I could see I should be strongly of opinion that the Cadastral Survey of Behar, which it is intended to set on foot shortly, will be productive of immense benefit, in that it will put an end to the troubles that have arisen from the absence of any Records defining and demarcating the different holdings and occupation rights.

Analysis of districts.

539. The Analysis of districts is a most important work, and one which in many cases has been well done. But it has, so far, had reference mainly to the question of security against famine; what is now needed is, that there should be an analysis of districts with regard to their general agricultural capacity and condition. In such work the employment of trained "experts" will be very necessary.

Bombay.

The most elaborate work as yet done in the analysis of districts has been the compilation of the "Statistical Atlas of Bombay." This atlas comprises an immense amount of information and statistics respecting the agriculture of the different districts of the Bombay Presidency.

North-West Provinces and Oudh.

In the North-West Provinces and Oudh the Annual Reports of the Department give, from time to time, statistical maps showing the distribution of different crops throughout these Provinces.

Madras.

In Madras the exhaustive analysis of a few districts has been undertaken, and in these the agricultural features have been set out. Of this nature are the Reports on the Cuddapah District, and upon Kurnool, both by Mr. C. Benson. I should also add here the valuable "Manual of Coimbatore," by Mr. F. A. Nicholson, of which I have made copious use in this Report.

Nothing has yet been done in this direction in the Central Provinces or in the Punjab, beyond what is contained in different Settlement Reports.

Central Provinces. Punjab.

In Bengal, however, a few districts have been specially reported upon, notably the Dacca District by Mr. Sen, and the Lohardaga District by Mr. Basu. I have read both of these Reports with considerable interest, and I think it would be a great advantage if the work were continued successively for the different districts throughout the Presidency.

Bengal.

540. Under "Measures of Protection" are included the establishment of "Fuel and Fodder Reserves;" the formation of plantations along canal banks and railway lines; arboriculture; irrigation; *taccavi* advances for digging wells, and for other purposes; reclamation of ravine and salty land (*usar*); embanking of land; emigration, &c. Sufficient has already been said under each of these headings.

Measures of protection.

541. Under "Agricultural Experiments, including Farms," it is the general rule to mention Agricultural Shows. These call for special note here. The plan of having periodical Agricultural Exhibitions is in vogue in Madras, Bombay, the North-West Provinces, and Bengal. It cannot be said to have been universally successful, and in several instances it has been decided to give up Shows which were formerly held regularly. The non-success has been, perhaps, most marked in Madras, and what appears to me the chief reason of failure is, that the Shows have merely been held because the Provincial Agricultural Departments ordered that they should be held, and not as the outcome of any general interest on the part of the people or of would-be exhibitors. During my tours I had the opportunity of visiting two or three Agricultural Shows, and I was much struck by the differences between them, even in the case of districts not very far apart. Thus, the first one I went to, viz., that at Saharanpur, though it was interesting in some respects, compared very badly, alike in the exhibits and in the interest taken, with the Show held a little later on at Meerut (Nauchandi Fair). I put this down mainly to the lack of local interest taken in the former, and to the little encouragement given by the English officials. In short, I believe that the success of a Show depends in great measure upon the efforts of the individual Collector or other resident officer, and that he has it largely in his power to make the Show a success or the reverse. Where, as I found to be the case in Madras, a Show was held mainly because the Government had decided that there should be one, it is not to be wondered at that the interest aroused was small. At Saharanpur no effort appeared to have been made to foster local industries, and the exhibition of local work was very inferior; at Meerut, on the contrary, the exact reverse was the case, and an admirable collection of the results of native and local talent was to be seen. Turning to the more agricultural side, I must say that I was quite surprised to see at Meerut a Show which would by no means have compared unfavourably with the Shows of some of

Agricultural Shows.

Success depends on individual efforts.

Exhibition of local industries.

our local Agricultural Societies in England. Horses and cattle especially made an excellent exhibition; whilst ploughing matches, trials of water-lifts, the working of the "cream-separator," and demonstration of English systems of butter-making, along with a large display of flowers, fruit, and vegetables, constituted a highly interesting and satisfactory Show.

Horse ring good

At the Meerut Show I noticed particularly the horse ring. It was admirably constructed, and quite picturesque with its enclosure of bamboo fencing topped with straw. The arrangements for the entry and exit of the horses, and for sending them round the ring, as also for the judging, were capital.

In some matters I would venture to suggest possible improvements.

Definite fixtures

I have seen it mentioned that in some cases the dates on which Shows are to be held are not fixed long enough ahead, and are altered after they have been once fixed; also that they are not sufficiently advertised. Both of these points must militate against the success of a Show. The fixtures ought to be made well ahead, and the dates be rigorously kept to, so that the Provincial Agricultural Department can issue, in advance, a list of the Show fixtures for the whole year. If dates are changed or if fixtures are left uncertain, people are sure to lose interest, and it also prevents proper advertisement being given to a meeting.

Good advertisement

The notices of the Show should be in the vernacular, and the more widely distributed they are the better.

Annual Provincial Show

It is well worth considering whether it would not be a good plan to follow the plan adopted by the Royal Agricultural Society of England, and to have one Great Show annually in a Province (the *locale* being changed from year to year), this taking in turn the place of the ordinary local Show held in any particular district. To this Show the Government subsidy might be confined, and a regular *rota* being determined upon, each district would be visited in turn, and more outside interest be aroused.

Practical judges.

Next, every effort should be made to get good practical judges. It is, I know, the practice always to turn to the Collector, or to the Director of the Agricultural Department, but it does not at all follow that they are the best agricultural judges.

System of judging at Horse Shows.

In the awarding of prizes for horses, I noticed that as many as five judges are frequently appointed, one judge taking into account, strength, another judge, quality, a third, soundness, and so on; 20 points may be awarded for each item, and the decision is given according to the highest total found on adding up the marks which each judge awards in his particular section. There is, however, no separate veterinary examination. I very much doubt whether it is in the power of any judge to examine and to allot exact marks for one individual quality possessed by a horse, apart from the others which it has; it is rather by a setting-off of one against the other that a judge should base his award. Besides, the difference of standard necessarily adopted when as many as five judges officiate at once, introduces errors which, I believe, are greater than the advantages gained by collecting the opinions of several different judges. As a consequence, on looking into the figures when made up to a maximum of 100, I found that the differences, even with this large number of marks, were generally very small, and it was seldom that as much as 20 marks separated the best from the worst horse in a class, although the judges allowed to me that the real differences amounted to very much more; and so, too, it proved, for, in the not infrequent case of a "tie" occurring, the judges, without hesitation, expressed their decided preference for one animal over another, although the totals of the marks obtained on the individual system of judging were equal. There should, I think, be a veterinary examination of the horses, and unsoundness ought to *disqualify* and not merely to *reduce* the marks awarded.

Horse fair.

A Horse Show loses much in interest and appearance by the plan generally adopted of having the horses tethered outside, and forming practically a Horse Fair, instead of the horses being arranged in classes, and being put side by side so that they can be compared. I was told that this arises from the fact of one man being in charge, possibly, of a number of different horses, and not being able to attend entirely to one; still it is a defect.

Catalogue.

Another want in connection with Agricultural Shows is that of a Catalogue. The issue of a catalogue with corresponding numbers on the exhibits would much add to the interest taken.

Poultry at Shows.

From what I saw of poultry exhibited at Shows, I thought that very considerable improvement might be effected if more attention were paid to breeding and rearing.

Prizes for grain samples.

The system of awarding prizes for small samples of grain is open to great abuse. Quite small bags, sample bags in fact, of grain are allowed to compete for prizes, and there is not the least security that the specimen is at all representative of the crop from which it is supposed to have come. It is quite easy to pick over by hand a sample of wheat or other grain and to make it look excellent. But there is not any certainty that the sample exhibited has come off the field of the particular exhibitor. If prizes are awarded for grain they should be for large bagged and sealed samples, or else for corn in the straw, and they should be duly certified by some responsible person. But what I would much prefer to grain prizes is, that prizes should be given for excellency of cultivation, or for the best crop grown on a farm or field,—in fact, "farm prizes." This would do a great deal more than grain prizes in stimulating improvement, and would be free from the objections to the latter.

Farm prizes preferable.

Bona fides of exhibitors.

In regard to the exhibitors themselves, more care should be exercised in order to ascertain that they are *bonâ fide* exhibitors and cultivators. There is little doubt that in many cases men have made it a regular business to "farm" the prizes offered, by the aid of some particular exhibit of which they have obtained the use, though they may not be the genuine owners or exhibitors. Such abuse must have the effect of keeping the genuine cultivators from exhibiting at Shows.

Trials of implements.

The last point to which I shall refer in this connection is the trial of implements.

Without doubt, a considerable amount of interest is aroused by competitions of this kind on Show grounds, but I am afraid that

Agricultural Departments should not compete with purchased implements.

they are not always carried out with sufficient care, and it would be much more satisfactory if more exhaustive trials were conducted at Experimental Farms. The latter are the places where such trials can best be made; and in the case of new implements, they should be submitted to rigorous tests before the *imprimatur* of the Agricultural Department is placed upon them. Again, it is the general practice for Provincial Agricultural Departments to exhibit at the various Shows, and to enter for competitive trial a number of implements of different makes which have been purchased by the Department. This appears to me hardly fair upon the makers or inventors of the implements, for the success or non-success depends very much upon the particular implement which the Department happens to have, the time at which it was purchased, and the way in which it has been kept and used. Thus, a sugar-mill of a particular make, which the Department has bought some years previously, and has probably used also in the meantime, may be brought into competition with a brand-new machine exhibited by some rival maker. If there are to be these competitions, the credit of the makers should not be dependent upon a machine exhibited by someone other than themselves, but they should have the opportunity of being represented by the latest and very best machine which they can turn out at the time; after that, in the event of failure, they would not have any reason to complain that they had not been fairly represented.

I notice that one year, in a competitive trial of sugar-mills at Saharanpur, the number of points awarded to a mill exhibited by the makers themselves was 88, while one of a different make and exhibited by the Agricultural Department had 87 points given to it. Such minute distinctions as these, under the conditions of a rough trial, ought not to be drawn, and the fame of one firm should not be made at the expense of another, when there is no practical difference between rival exhibits, and more especially when one firm is represented by a new machine, and the other by one probably of earlier date. The Agricultural Departments would do well, I think, to refrain from entering as competitors, and to confine themselves to demonstrating the working of different implements brought under their notice.

Shows in Bombay.

In the Bombay Presidency some six different Shows are held annually, the annual Government contribution to them being about Rs. 8,000. The Horse Fairs at Poona, Ahmedabad, and Sind are the best-known Shows, the last named being generally very successful.

North-West Provinces and Oudh.

In the North-West Provinces and Oudh the chief Shows are those at Aligarh, Meerut, Saharanpur, Etawah, and Muttra. Government awards over Rs. 1,000 annually for cattle prizes. In connection with these Shows the services of Mir Muhammad Husain, the Assistant Director of Agriculture, are invaluable, and to his energy their success is in large measure due.

Madras.

In Madras the chief Shows are those at Bellary and at Salem.

Bengal.

In Bengal occasional Shows are held at about five different towns.

Purchase of horses by Army Remount Department.

At the different Shows held throughout the country a stimulus is given to Horse-breeding by the purchase of young stock for the

Army Remount Department, some of the officers of which attend the Shows and buy animals which they think likely to meet army requirements in the future. Mares are also selected to be "branded" mares, and thus become eligible to be served by Government stallions.

Other branches of the work of Agricultural Departments.

542. Under the head "Experimental Farms" are also classed seed distribution and sale of implements. Cattle-breeding, veterinary establishments, &c., which come under the next head, have also been fully referred to before.

The other heads under which the work of Agricultural Departments falls do not call for special mention by me.

Organisation of Departments in different Provinces.

Punjab.

543. The Organisation of Provincial Departments of Agriculture is not alike throughout India. In the Punjab, for instance, there is no separate Department, but it merely forms a part of the Land Revenue Administration, its Report being included in the general one of the Administration, and not being given under the different heads prescribed by the Government of India.

Central Provinces.

In the Central Provinces there is a Commissioner of Agriculture, who combines with his duties those of Commissioner of Settlements.

Madras.

In Madras there was no separate Department until 1882, and the Director is not a travelling one, but always remains at head-quarters.

Bengal.

In Bengal there was no separate Department until 1885, and the one then started was established only as a temporary or tentative measure.

North-W Provinces.
Bombay.

In the North-West Provinces, and in Bombay, there are separate and complete organisations.

The future policy and requirements of Agricultural Departments.

544. The Agricultural Department has frequently been found fault with on account of the mistakes which it has made, and of the number of minor matters which it has turned its attention to, while neglecting the larger and more pressing questions. It has been pointed out that the Department has exercised itself about the introduction of iron ploughs, of cotton-cleaning machines (*ginning* machinery), and has spent time and money in attempting impossible hybridisations of cotton, whilst it has declined to tackle urgent matters such as the indebtedness of the cultivating classes, the over-assessment of the land, and the working of the system of loans for agricultural improvement. It is not for me to defend the Department from such charges, or to say that they have not been justly made, but it is clear to me that the work of the Department has been greatly hindered by three main causes, want of sympathy, imperfect machinery, and want of money. I have attempted to prove that the first should not be any longer shown, that the second is capable of improvement, and that, thirdly, the further expenditure of money is an absolute necessity for the accomplishment of any real good.

What line exactly the Department should take up depends entirely upon the machinery with which it is fitted, and upon the means placed at its disposal. I have indicated that I consider that one great problem which will have to be met in the immediate future is the provision of "Fuel and Fodder Reserves," in order to supply wood to take the place of dung as fuel, and so to set free the dung for its proper use as manure to the land. I have also expressed an opinion that a share in the management of loans (*taccavi* system) for digging wells and for other agricultural improvements might with advantage be entrusted to the Agricultural Department, and that the Department should have power to enquire into cases of over-assessment, and to recommend exemption from assessment in special cases, in order to encourage the carrying out of agricultural improvements. But such measures cannot be carried out without a more extended machinery than the Department possesses, and without its having placed at its disposal considerably larger means than in the past. That a larger expenditure is warranted I fully believe, and I am confident that the outcome will be the bettering of the condition of the agricultural classes, and the increase of revenue to the State.

In conclusion, I would urge once more the need of having uniformity and continuity of policy. In a country like India, where conditions are so diversified, there must of necessity be differences of method in the working out of any policy, and these methods may have to be altered according as the conditions alter. But there should be uniformity of general principle, and one policy alike should characterise the action of Agricultural Departments, both Imperial and Provincial.

CONCLUSIONS.

545. CONCLUSIONS.

In order that Agricultural Departments may be equipped with the right kind of men to carry out the agricultural improvements which have been suggested in this Report, it is very desirable that more attention should be given to the early training in a scientific direction of future Civil Servants, and that, on their arrival in India, they should have more opportunities of acquainting themselves with the agricultural conditions of the country. This will be best effected by giving more weight to Natural Science at the open competition and at the final examination, and by drafting a certain proportion of the men, on arrival in India, into the Department of Land Records and Agriculture. Out of those who have distinguished themselves by their proficiency in science, and subsequently by their interest in agriculture, the future Agricultural Directors might advantageously be selected.

The position of Agricultural Director should be invested with some administrative power, and the granting of loans for agricultural improvements should be in part managed by the Agricultural Departments. Analyses of districts should be made, in respect not only of security from famine, but also of general agricultural conditions and requirements.

In order that the work of Agricultural Departments may proceed in the right direction, there are two essentials, (1) a more competent machinery, and (2) an increased expenditure of money upon agricultural improvement.

Lastly, there must be uniformity of principle in the action of Imperial and Provincial Agricultural Departments, and a continuity of policy throughout.

546. RECOMMENDATIONS.

RECOMMENDATIONS.

That more weight be given to Natural Science in the open competitions for the Civil Service, and at the final examination of probationers.

That a certain proportion of junior Civilians, on arrival in India, be drafted into Departments of Land Records and Agriculture.

That Agricultural Directors be chosen from those men who have distinguished themselves in Natural Science, and subsequently by their interest in Agriculture.

That Agricultural Directors be given some administrative powers, and that a share in the management of Loans for Agricultural Improvement be entrusted to Agricultural Departments.

That a considerably increased amount of money be placed at the disposal of Agricultural Departments for expenditure upon Agricultural Improvement.

APPENDIX.

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APPENDIX.

APPENDIX.

In this Appendix are given several analyses made by me of soils, waters, manures, feeding materials, and grain samples, which may be of interest as bringing out some of the points mentioned in my Report, but which, for fear of overburdening it, I did not consider desirable to set out fully in the body of the Report. For the purpose of completeness, some analyses already given in the Report are repeated, and explanatory notes are added where necessary.

A. (*see* Chap. V., paragraphs 58–68.)

Composition of Wheat Soils from the Sirsa sub-division (Punjab).

(Soils dried at 212 ° F.)	No. 1. From Ghaggar Bed.	No. 2. From Sotar Valley.	No. 3. From Gudah.
*Organic Matter and combined Water	·63	2·67	·65
Oxide of Iron	2·58	4·32	1·62
Alumina	1·72	5·85	2·02
Carbonate of Lime	2·96	2·57	3·33
Magnesia	1·07	1·97	1·07
Potash	·39	·74	·31
Soda	·15	·08	·11
Phosphoric Acid	·17	·23	·19
Insoluble Silicates and Sand	90·33	81·57	90·70
	100·00	100·00	100·00
*Containing Nitrogen	·07	·02	trace.
Equal to Ammonia	·08	·02	trace.

No. 1 is soil from the bed of the Ghaggar, a stream which is crossed on the journey between Kalka and Umballa. In the lower part of the course the bed is sandy. The soil was light-coloured, containing much fine sand with micaceous particles.

No. 2 is soil from the Sotar Valley, which seems to have been formerly the bed of the Ghaggar; the bottom is firm and even heavy soil. It is reckoned to be the best soil in Sirsa. The sample analysed was free from mica, and was not nearly as fine and sandy as No. 1.

No. 3 is a soil called *Rousli*, a name applied in Delhi and the North-West generally to any sandy loam. It is very like No. 1 but is even finer and more sandy.

The distinguishing features of these soils are that they are well supplied with lime and mineral constituents generally, but are deficient, more especially Nos. 1 and 3, in organic vegetable matter, while all of them are very poor in nitrogen, No. 3, indeed, containing only traces. No. 2, the heaviest soil, is decidedly the richest, but is deficient in nitrogen. The quantities of phosphoric acid, potash, magnesia and lime are, more particularly in the case of No. 2, very good, and point to the probability of mineral constituents existing in the soils in sufficient amount to meet the demands of a long succession of crops. Renewal, however, both of vegetable matter and of nitrogen will, I consider, be very necessary in all three cases. Green-manuring, or the use of cattle-dung or similar nitrogenous organic materials, will be the best means of supplying the deficiency.

(For further remarks *see* Chap V., paragraphs 58-68.)

B. (*see* Chap. V., paragraphs 63-68.)

Composition of Coffee Soils from Munjerabad, Mysore.

Soils dried at 212° F.	No. 1.	No. 2.	No. 3.
*Organic Matter and combined Water	7·15	13·73	13·30
Protoxide of Iron	trace.	1·54	2·54
Peroxide of Iron	5·04	11·83	12·02
Alumina	20·39	11·53	13·81
Lime	·20	·32	·32
Magnesia	·28	·32	·30
Potash	·25	·10	·10
Soda	·12	·12	·09
Phosphoric Acid	·13	·15	·10
Sulphuric Acid	·03	·02	·04
Nitric Acid	—	—	—
Chlorine	·01	—	—
Insoluble Silicates and Sand	66·40	60·34	57·38
	100·00	100·00	100·00
*Containing Nitrogen	·032	·20	·20
Equal to Ammonia	·039	·24	·24

No. 1. Hindiganhulla, Ida Munoo, considered good coffee soil.

No. 2. Bartchinhulla, Upper Toddyman's field, where coffee does not do well.

No. 3. Bartchinhulla, Kemp Munoo, from Nui Gondas Heetloo, where coffee does not do well.

It is primarily noticeable in these soils, as distinguished from the Wheat soils given in Appendix A., that the amounts of organic matter are very much larger, and that the soils also generally contain larger proportions of nitrogen. On the other hand, there is very much less lime, and, indeed, what I should consider a decided deficiency of it, so that liming would, I think, be very advantageously practised. Potash, too, is present in much smaller quantity than in the Wheat soils, and, for the requirements of the fruit (that is, the coffee berry), the amount does not seem sufficient, at all events, in the case of Nos. 2 and 3. Manuring with wood ashes, or some other source of potash, would be beneficial in all cases. Phosphoric acid is present in fair, but not in large, amount, and bones may still be advantageously used, because the fact that they yield lime at the same time as phosphoric acid must not be overlooked. The presence of iron and alumina compounds in quantity is a distinguishing feature of these laterite soils. On the other hand, the supply of nitrogen appears to be of lesser importance in the case of coffee, and the superiority of soil No. 1 to Nos. 2 and 3 would seem to rest in the excess of potash, the lesser proportion of iron salts, and very probably also in the fact that these latter are present in the more fully oxidised state of peroxide, and not in that of protoxide of iron.

(For further remarks *see* Chap. V., paragraphs 63-68, and Chap. XIV., paragraph 363.

C. (*see* Chap. VI., paragraph 99.)

Composition of Two Samples of Well Water and Canal Water from Rawatpur, near Cawnpore, taken April 1890.

——	Well Water.	Canal Water. (Cawnpore Branch of Lower Ganges Canal.)
	Grains per gallon.	Grains per gallon.
Total Solid Residue (at 130° F.) - - - - - -	71·93	15·16
Containing—		
Oxide of Iron and Alumina	—	·28
Lime - - - - - -	7·56	3·36
Magnesia - - - - -	6·30	1·68
Potash - - - - -	·37	·80
Soda - - - - - -	20·53	1·40
Chlorine - - - - -	9·20	·30
Phosphoric Acid - -	·73	·06
Nitric Acid - - - -	5·50	—
Sulphuric Acid - - -	6·30	1·06
Soluble Silica - - - -	1·96	1·26
Free Ammonia - - - -	·002	·001
Albuminoid Ammonia - -	·005	·007

Combining the above constituents together in the forms in which they are probably present in the waters, the composition of the samples may be represented as follows :—

——	Well Water.	Canal Water.
	Grains per gallon.	Grains per gallon.
Carbonate of Lime - -	4·09	4·55
Carbonate of Magnesia -	13·23	3·52
Carbonate of Soda - -	16·41	2·39
Carbonate of Potash - -	—	·60
Sulphate of Lime - -	10·71	1·80
Phosphate of Lime - -	1·59	·13
Chloride of Potassium -	·59	·63
Chloride of Sodium - -	14·69	—
Nitrate of Soda - - -	8·66	—
Oxide of Iron and Alumina	—	·28
Soluble Silica - - -	1·96	1·26
Total Solid Constituents -	71·93 grains per gallon.	15·16 grains per gallon.
Free Ammonia - - -	·002 „	·001 „
Albuminoid Ammonia -	·005 „	·007 „

(For detailed remarks on the above analyses *see* Chap. VI., paragraph 99.)

D. (*see* Chap. VII., paragraph 121.)

Composition of Indian Cattle-dung.

[Solid Droppings of Cattle.]

—	Dung from Lean Cattle. (air-dried)	Dung from grain-fed Cart (*bandy*) Bullocks. (air-dried)
Moisture	19·59	17·86
° Organic Matter	59·26	61·89
† Mineral Matter (ash)	21·15	20·25
	100·00	100·00
* Containing Nitrogen	1·34	1·08
Equal to Ammonia	1·62	1·31
† Containing		
Insoluble Siliceous Matter	14·43	16·75
Oxide of Iron and Alumina	3·36	1·36
Lime	1·04	·85
Magnesia	·44	·30
Potash	1·16	.60
Soda	·34	·26
Phosphoric Acid	·47	·54
Equal to tribasic Phosphate of Lime	1·03	1·18

(For detailed remarks on above *see* Chap. VII., paragraph 121.)

E. (*see* Chap. VII., para. 121.)

Composition of Ashes of Indian Cattle-dung, after burning.

Moisture	2·04
° Organic Matter	2·40
Oxide of Iron and Alumina	9·26
† Phosphoric Acid	1·37
Lime	1·76
‡ Alkalies, Magnesia, &c.	2·97
Insoluble Siliceous Matter	80·20
	100·00
° Containing Nitrogen	·17
Equal to Ammonia	·20
† Equal to tribasic Phosphate of Lime	2·99
‡ Containing Potash	2·05

F. (*see* Chap. VII., paragraph 146.)

Composition of Drainings from Manure heap (*gobra tipi*) taken at Munjerabad, Mysore.

Water and Volatile Matters	97·29	
Non-volatile Organic Matters	1·23	2·71 Total Solid Residue
* Mineral Matter (ash)	1·48	
	100·00	
Total Nitrogen	·144	
Equal to Ammonia	·174	
*Containing—		
Silica	·316	
Oxide of Iron and Alumina	·243	
Lime	·075	
Magnesia	·059	
Potash	·426	
Soda	·029	
Phosphoric Acid	·050	
Equal to tribasic Phosphate of Lime	·110	
Specific gravity at 60 ° F.	1·025	

A standard English analysis of Drainings from Manure heaps (Johnston & Cameron's Elements of Agricultural Chemistry and Geology, page 330) gives the following figures :—

In 100 Parts.	Parts.
Total Solid Residue	1.939
Containing Chloride and Carbonate of Potash	·511
,, Phosphates of Lime and Iron	·104
Total Nitrogen	·044

Thus, the Drainings from the Indian Manure heap were slightly richer both in solid matter (including potash and phosphoric acid) than those quoted in the English analysis, and they contained considerably more nitrogen. It is evident, therefore, that allowing the drainings to go to waste is productive of considerable loss in India, equally as it has been found to be the case in England.

G. (*see* Chap. VII., paragraph 146.)

Composition of the Urine of Lean Cattle and Grain-fed Cart (*bandy*) Bullocks.

——	Lean Cattle.	Cart Bullocks.
Water and Volatile Matters	91·77	90·62
Non-volatile Organic Matters	5·29	7·64
* Mineral Matter (ash)	2·94	1·74
	100·00	100·00
Total Nitrogen	·956	1·168
Equal to Ammonia	1·161	1·418
* Containing—		
Silica	·004	·010
Lime	·161	·080
Magnesia	·249	·570
Potash	1·528	·643
Soda	·050	·020
Phosphoric Acid	·022	·022

(For detailed remarks *see* Chap. VII., paragraph 146.)

H. (*see* Chap. VII., paragraph 149.)

Composition of Leaves and Twigs used for Litter in Mysore.

———	1. Leaves.	2. Leaves (mainly *Jack-fruit* tree Leaves.)	3. Twigs.
Moisture - - - - -	10·72	10·73	11·63
° Organic Matter - - -	84·68	78·44	84·65
† Mineral Matter (ash) -	4·60	10·83	3·72
	100·00	100·00	100·00
* Containing Nitrogen - -	1·18	·91	·72
Equal to Ammonia -	1·43	1·10	·87
† Containing—			
Silica - - - - -	·04	3·53	·09
Oxide of Iron - -	·29	—	·05
Alumina - - -	·03	—	·44
Lime - - - - -	1·04	—	1·25
Magnesia - - -	·51	—	·33
Potash - - - -	1·09	·73	·68
Soda - - - - -	·07	—	·11
Phosphoric Acid - -	·10	—	·13
Equal to tribasic Phosphate of Lime - -	·22	1·07	·28

(For detailed remarks *see* Chap. VII., paragraph 149.)

J. (*see* Chap. VII., paragraph 127.)

Composition of Indian Oil-cake refuse used as Manure.

	Castor-oil Bean Cake or *Castor poonac.*			*Hongay* (*Pongamia glabra*) *poonac.*
———	1. —	2. From Calicut (milled).	3. From Mysore.	
Moisture - - - - - -	10·72	9·49	10·65	12·19
° Organic Matter - - - -	82·88	74·91	84·01	83·42
Total Phosphates - - -	5·29	4·95	4·01	2·37
Alkaline Salts, &c. - - -	·42	2·90	·78	1·98
Insoluble Siliceous Matter -	·69	7 75	·55	·04
	100·00	100·00	100·00	100·00
° Containing Nitrogen - -	4·94	4·35	4·89	3·54
Equal to Ammonia - -	5·99	5·28	5·94	4·29

Sample No. 2 was "milled," *i.e.* crushed by machinery; the other samples were not, but were merely the refuse (after extraction of oil in the native way) roughly pressed together without the aid of machinery.

K. (*see* Chap. VII., paragraph 127.)

Composition of Indian Feeding-stuffs for Cattle.

——	Earth-nut Cake. (Decorticated.)	Earth-nut Cake. (Undecorticated.)	Gingelly, or *Til* seed Cake.	Niger seed Cake.	*Hongay* bean (*Pongamia glabra*).
Moisture	8·10	9·80	8·03	11·90	9·58
Oil	7·26	6·50	13·01	6·43	9·23
*Albuminous Compounds	47·81	47·31	38·92	34·01	24·93
Carbohydrates, Digestible Fibre, &c.	25·02	19· 8	22·12	22·27	47 42
Woody Fibre	4·86	10·26	4·70	17·14	4·70
†Mineral Matter (ash)	6,95	6·85	13·22	8·25	4·14
	100·00	100·00	100·00	100·00	100·00
*Containing Nitrogen	7·65	7·57	6·22	5·44	3·99
†Including Sand	3·25	—	2·89	1·25	—

——	*Mahua* (*Bassia latifolia*) refuse from Distillery.
Moisture	17·92
Oil	·46
*Albuminous Compounds	3·44
Gum, Mucilage, &c.	3·08
Sugar	64·40
Digestible Fibre	3·14
Woody Fibre	2·13
†Mineral Matter (ash)	5·43
	100·00
*Containing Nitrogen	·55
†Including Sand	2·90

The large amount of sugar in the *Mahua* refuse is noticeable.

L. (*see* Chap. VII., paragraph 136.)
Composition of Indian Bone-meals.

	1. (Pure.)	2. (Pure.)	3. (Adulterated.)	4. (Adulterated.)
Moisture - - - - - -	8·50	7·76	6·50	7·32
*Organic matter - - - -	28·85	29·33	18·75	23·43
†Phosphoric Acid - - - -	25·00	24·08	18·15	22·08
Lime - - - - - -	33·79	32·56	37·55	33·88
Magnesia, Alkalies, &c. - -	3·46	1·03	3·24	2·36
‡Carbonic Acid - - - - -		3·00	11·80	7·15
Insoluble Siliceous matter -	·40	2·24	4·01	3·78
	100·00	100·00	100·00	100·00
*Containing Nitrogen - -	4·12	4·04	2·78	3·35
Equal to Ammonia - -	5·00	4·90	3·38	4·07
†Equal to tribasic Phosphate of Lime.	54·58	52·83	39·62	48·21
‡Equal to Carbonate of Lime -	—	6·82	26·82	16·25

M. (*see* Chap. VII., paragraph 139.)
Composition of Materials used to adulterate Indian Bone-meal.
(Samples taken at Mazagon Dock, Bombay, 10th January 1891.)

	A.	B.	C.
Moisture - - - - - - -	3·29	—	4·37
Lime - - - - - - - -	43·78	33·23	40·43
Magnesia - - - - - -	1·35	—	20·00
Oxide of Iron and Alumina - -	4·78	7·65	2·30
*Carbonic Acid - - - - - -	29·64	24·64	28·55
Alkalies, &c. - - - - - -	4·70	5·83	4·05
Insoluble Siliceous Matter - - -	12·46	28·65	·30
	100·00	100·00	100·00
*Equal to Carbonate of Lime - -	67·36	56·00	64·89

A. Grey-coloured.
B. Shell-sand.
C. White. Probably powdered magnesian limestone.

N. (*see* Chap. XIV., paragraph 383.)

MECHANICAL ANALYSES of Samples of Indian Wheat taken from Threshing-floors of Cultivators in the Cawnpore district.

In chapter XIV., paragraph 383, I have given a table setting out the percentages of the various kinds of impurities found in six samples of wheat collected for me from threshing-floors of cultivators and cleaned in my presence.

It may be convenient, however, in addition to stating the impurities under each heading, according as they happen to be large seeds and lumps of earth, or chaff, or small seeds and fine earth, &c., to give the impurities under the headings that are recognized by the London Corn Trade Association.

No.	Village.	Barley, &c.*	Dirt.†	Total other than Wheat.
		per cent.	per cent.	per cent.
1	Binaitpur - - -	·072	·054	·126
2	Cawnpore - - -	1·06	·600	1·660
3	Gotaya - - - -	1·120	·590	1·710
4	Likhanpur - - -	1·010	1·010	2·020
5	Rawatpur - - -	·390	·280	·670
6	Nawabganj - - -	·660	·540	1·200
	Average - -	·720	·512	1·232

* The term "barley, &c.," includes all grain of intrinsic value, such as barley, peas, linseed, &c.

† The term "dirt" includes earth, chaff, and miscellaneous weed seeds.

No.	——	Barley, &c.	Dirt.	Total other than Wheat.
		per cent.	per cent.	per cent.
7	Bulk in Cawnpore Market - - -	2·71	·92	3·63

(For further details *see* Chap. XIV., paragraphs 383–4.)

O. (*see* Chapter XIV., paragraph 388)

MECHANICAL ANALYSES of Samples of Linseed taken from Cultivators' Stores and Threshing-floors.

Mechanical Analyses of 18 Samples of Linseed from Bilaspur district, Central Provinces.

No. of Sample.	Whence taken.	Impurities removed by sieving.		Impurities removed by hand-picking.	
		Sieved Linseed.	Impurities.	Pure Linseed.	Total Impurities.
		per cent.	per cent.	per cent.	per cent.
1	From threshing-floor -	95·62	4·38	94·49	5·51
2	„ store in house -	90·21	9·79	87·70	12·30
3	„ threshing-floor -	96·18	3·82	94·26	5·74
4	„ „ „ -	94·17	5·83	92·89	7·11
5	„ store in house -	97·07	2·93	95·81	4·19
6	„ „ „ -	93·83	6·17	92·07	7·93
7	„ „ „ -	90·08	9·92	87·88	12·12
8	„ „ „ -	95·35	4·65	93·61	6·39
9	„ „ „ -	95·33	4·67	93·10	6·90
10	„ „ „ -	91·32	8·68	89·83	10·17
11	„ „ „ -	94·31	5·69	92·93	7·07
12	„ „ „ -	94·24	5·76	92·81	7·19
13	„ „ „ -	94·72	5·28	93·12	6·88
14	„ „ „ -	96·03	3·97	94·18	5·82
15	„ „ „ -	92·12	7·88	89·33	10·67
16	„ „ „ -	96·29	3·71	95·52	4·48
17	„ „ „ -	96·28	3·72	95·36	4·63
18	„ „ „ -	97·86	2·14	96·66	3·34
		Average - - -		92·87	7·13

Mechanical Analyses of Four Samples of Linseed from Raipur district, Central Provinces.

No. of Sample.	Whence taken.	Impurities removed by sieving.		Impurities removed by hand-picking.	
		Sieved Linseed.	Impurities.	Pure Linseed.	Total Impurities.
		per cent.	per cent.	per cent.	per cent.
19	Consignment to a Trader.	98·53	1·47	97·77	2·23
20	Raipur Market - -	94·88	5·12	92·85	7·15
21	„ - -	93·59	6·41	91·97	8·03
22	„ - -	95·07	4·93	93·16	6·84
		Average - - -		93·94	6·06

anical Analyses of Two Samples of Linseed from Jubbulpore district, Central Provinces.

Whence taken.	Impurities removed by sieving.		Impurities removed by hand-picking.	
	Sieved Linseed.	Impurities.	Pure Linseed.	Total Impurities.
	per cent.	per cent.	per cent.	per cent.
- - - - -	96·38	3·62	94·89	5·11
- - - -	97·20	2·80	96·72	3·28
	Average - - -		95·81	4·19

ıanical Analyses of Two Samples of Linseed from Damoh district, Central Provinces.

- - - -	94·45	5·55	92·84	7·16
- - - -	94·21	5·79	90·36	9·64
	Average - - -		91·60	8·40

hanical Analyses of 11 Samples of Linseed from Nagpur district, Central Provinces.

Stored in house - -	96·33	3·67	94·97	5·03
" " - -	97·22	2·78	96·24	3·76
From threshing-floor -	99·00	1·00	98·10	1·90
Stored in house - -	98·00	2·00	96·76	3·24
Brought to Ralli Brothers' store -	98·19	1·81	97·34	2·63
From threshing-floor -	96·46	3·54	94·61	5·39
" " -	97·20	2·80	96·05	3·95
" " -	95·12	4·88	91·44	8·56
" " -	96·70	3·30	94·51	5·49
" " -	96·59	3·41	95·02	4·98
" " -	99·15	·85	98·60	1·40
	Average - - -		95·79	4·21

SUMMARY.

e of Samples from all the Five Districts -	94 per cent. Pure Linseed.	6 per cent. Total Impurities.

MY TOURS, 1889-90.

TOURS.

(*See* Map of Tours.)

Arrival in India, December 10th 1889.

First Tour - Dec. 10th 1889 to May 19th 1890.
Second Tour - July 14th 1890 to Sept. 12th 1890.
Third Tour - Nov. 23rd 1890 to Jan. 10th 1891.

Departure from India, Jan. 10th 1891.

Residence in India, 13 months.

First Tour.

NOTE.—*The references in the following account are to* PARAGRAPHS *in the foregoing Report.*

First Tour, Dec. 10th 1889 to May 19th 1890.

1889 :

London, Nov. 21. Marseilles, Nov. 23.

ON November 21st 1889 and within a week from the time that my delegation to India was decided upon, I left London for Marseilles, and at the latter port joined the Peninsular and Oriental Company's steamship "Bokhara," the vessel which, singularly enough, had conveyed Sir James Caird to India when he went out in October 1878 as one of the Famine Commissioners. Hardly was I on board before I came in close and pleasant acquaintance with Indian agriculture in the person of Mr. R. H. Elliot, of Clifton Park, Kelso, whom I had previously known as a Scotch agriculturist, and who was then on his way to his coffee estates in Mysore. The deep interest which Mr. Elliot felt in the progress of agriculture in India, and in any movement for its improvement, rendered our meeting an invaluable assistance to me, and one which I had reason throughout my tour to be extremely glad of. Our daily conversations, and a study of the "Statistical Atlas of India" (a copy of which Sir Charles Bernard had kindly lent me), soon convinced me that I had before me a difficult and responsible task. On board the "Bokhara" I met Mr. Justice Jardine, of the High Court, Bombay, Mr. Harvey James, Secretary to the Government of India in the Legislative Department, Dr. Warburton (Kapurthala), Mr. H. F. Brown (Kilburn & Co., Calcutta), Mr. Apperley (indigo planter, Bettiah), one or two tea planters, a Punjab irrigation officer, Mr. Oldham (late of the Public Works Department), and others more or less connected with Government Departments or with agriculture.

Bombay, Dec. 10.

On coming within sight of Bombay I received a cordial invitation from Lord Reay, the Governor of Bombay, to go direct to Government House, Malabar Point. Here, in addition to the Governor, I met Mr. Ozanne, Director of the Bombay Department of Agriculture, and Dr. Theodore Cooke, Principal of the College of Science, Poona. At an informal meeting next day with these gentlemen, Mr. Elliot, and Mr. Bhimbhai, Assistant Director of Agriculture, Bombay, we discussed the general points to which my attention would specially be directed during my tour.

Poona, Dec. 12.

On December 12th I travelled with Dr. Cooke to Poona, and there met Mr. Howman, who had come over from England in order to introduce the mechanical "cream-separator" and English systems of butter-making (para. 264). December 13th was spent in going over the College of Science (para. 520), and the Experimental Farm (para. 483) attached to the College. Returning to Bombay, I left again on the evening of December 14th for Pachora, Mr. Bhimbhai accompanying me. We were met at Pachora by

Bhadgaon, Dec. 15.

Calcutta, Dec. 18-22.

Mr. P. R. Mehta, a former student and diploma holder of Cirencester College, now the Superintendent of the Bhadgaon Experimental Farm. I inspected the Bhadgaon Farm (para. 482) that day, seeing the cold-weather (*rabi*) crops, and the Mysore herd of cattle. I left the following morning, having received directions to proceed at once to Calcutta to meet Sir Edward Buck, Secretary of the Imperial Agricultural Department, before he went on tour. Arrived at Calcutta, I spent from the 18th inst. to the 22nd inst. in making the acquaintance of the principal officials of the Agricultural Department, and in calling upon representatives of commercial houses more or less connected with agriculture. His Excellency the Viceroy (the Marquis of Lansdowne) gave me the honour of an interview, and I met also at Calcutta the Hon. Mr. Hutchins, Member of Council for the Agricultural Department; Colonel Ardagh, Private Secretary to the Viceroy; Mr. Harvey James; Mr. Finucane, Director of Agriculture, Bengal Presidency; Dr. W. King, Director of the Geological Survey; Dr. George King, Director of the Botanical Gardens; Mr. Muir-Mackenzie, Under Secretary Agricultural Department, Government of India; Mr. J. E. O'Conor, of the Financial Department; as well as Mr. N. Banerji and Mr. N. G. Mookerjee, of the Bengal Agricultural Department, two Natives who had previously been students at Cirencester College.

Messrs. Octavius Steel & Co. kindly gave me information in regard to the use of improved agricultural machinery; Mr. Ross (Kelly & Co.) as to the trade in and conditions of export of wheat and oil-seeds; Messrs. Mackillican & Co. and Messrs. Kilburn & Co. as to the trade in bones and other manures.

Cawnpore, Dec. 24.

Bilhaur, Dec. 24.

In camp, Dec. 24-28.

Cawnpore, Dec. 29.

Etawah, Dec. 30.

Aligarh, Dec. 31.

1890:

Agra, Jan. 1-3.

Sir Edward Buck was at this time about to leave Calcutta on a tour in part of the North-West Provinces, and thence through Agra, Gwalior, and Indore, to Berar, Hyderabad, and finally Coorg and Madras. As the Cawnpore district, to which he was first going, was the one in which Sir Edward had previously served, he thought it would be of advantage to me if I accompanied him, and this I was very glad to do. Mr. H. C. Hill, then Officiating Inspector General of Forests, was also of the party. The first halt was at Cawnpore, reached on December 24th, and here we met Mr. F. N. Wright, Collector of Cawnpore, Mr. W. B. Wishart, Secretary Upper India Chamber of Commerce, and Mr. Muhammad Husain, Assistant Director of Land Records and Agriculture, North-West Provinces and Oudh. The greater part of the day was taken up in examining the experiments which were being tried on reclaiming sterile salty land (*usar*) at two places near Cawnpore. The first was the Juhi enclosure (para. 75), and the second the Amramau farm (para. 75). A brief visit was also paid to the Cawnpore Experimental Farm (para. 478), and in the evening we pushed on to Bilhaur, where we went into camp. For the next few days we constantly shifted our quarters, moving from village to village, and in the course of our march I was enabled to get a capital view of the agriculture of this district of the North-West Provinces, and to gain from Sir Edward Buck much that was the result of his own experience as a district officer in these parts. The cold-weather (*rabi*) crops were then on the ground, including a good deal of wheat, and we also went over large stretches of salt-destroyed plains (*usar* land). Besides this, I had the opportunity of seeing, at the different halting places, the village records and maps of the village accountants (*patwaris*), and of learning how the Land Record system was maintained in these Provinces. Among the places at which we stopped were Aima. Sanda, and Kairnagar. On the morning of December 28th I left the camp, and, in company with Mr. Muhammad Husain, rode back to Bilhaur, and thence went by train to Cawnpore, where I made a close inspection of the Cawnpore Experimental Farm (para. 478), and of the workshops (para. 286) attached to it. On the evening of the 29th Mr. Muhammad Husain took me with him to Etawah, to show me the work that had been done in reclaiming ravine land along the banks of the Jumna, and in converting it into a "Fuel and Fodder Reserve" (paras. 70 and 181). We then journeyed to Aligarh, going, on December 31st, to the Chherat Farm (para. 75), where we saw the experiments which Mr. Muhammad Husain had been conducting on the reclamation of salty land (*usar*). This done, we made a short stay at Agra, and I again met Sir

Jhansi, Jan. 4.

Edward Buck, and travelled on with him to Jhansi. We stayed with Mr. Lang, the Commissioner of Jhansi, and early on the morning of January 4th set out for Raksha, in order to go over some of the rough hilly country overlooking Jhansi, on which efforts at reclamation had been made. This had been done by embanking the land, and thus preventing the rush of water down the sloping side; the endeavour has been made also to grow trees and grass, as well as to hold up water for irrigation purposes (para. 70).

Indore, Jan. 5–6.

Akola, Jan. 7–9.

From Jhansi we passed by rail through the fertile Nerbudda Valley, then bearing rich crops of wheat and oil seeds, and on to Indore, where we halted a day. We left on the 6th inst. for Akola, in Berar, where we again met Mr. H. C. Hill. I saw here the cultivation on the rich black cotton-soil which abounds in these parts.

From Akola we went, on January 9th, to Poona, *viâ* Bombay, and at Poona I parted company with Sir Edward Buck, he proceeding to Hyderabad, whilst I was to journey on with Mr. Hill towards Mysore and Coorg.

Poona, Jan. 11.

Bangalore, Jan. 13.

Mysore, Jan. 14.

Hunsur, Jan. 15.

Coorg Forests, Jan. 15–22.

During a short halt at Poona I again visited, on January 11th, the Poona College, and, in company with Mr. Woodrow (the Professor of Agriculture) and Mr. Dadina (the manager) the Poona Experimental Farm. The same evening I started off with Mr. Hill and Mr. Dickinson (lately Deputy Conservator of the Coorg Forests) on a tour which was to take me through the Coorg Forests, and to give me some idea of the working of a forest and of the duties and relations of the Forest Department. We travelled by rail through the Southern Mahratta country, past Belgaum, Dhárwar and Hubli, into Mysore territory, and halted at Bangalore After a short stay here, we proceeded to Mysore, which was reached on the 14th inst. On the 15th we drove out to Hunsur, and went once more into camp, being joined by Mr McKee, Deputy Conservator of the Coorg Forests. At Hunsur I saw the sandal-wood depôt of the Mysore Government, and also the timber depôt connected with the Coorg Forests (para 164). Our route from Hunsur led us through the Hutugat and Nalkeri Forests, and taking daily, as we did, long marches through the woods, I had a capital opportunity of seeing the details of forest management, the establishment of plantations, the spread of forests by the securing of natural reproduction, the system of protection by means of fire lines, and the methods of exploiting timber. Teak (*Tectona grandis*) and *Honne* (*Pterocarpus marsupium*) were the most valuable trees grown, as well as bamboos.

Polybetta, Jan. 22.

Mercara, Jan. 23.

From Mr. Hill I heard a good deal about the Forest School at Dehra Dun, where the native forest subordinates are trained, and which I visited at a later date We camped on the 16th at Murkal, in the eastern zone of the Hutugat Forest, and the following day rode into the middle zone. On the 18th we passed into the Nalkeri Forest, and encamped at Nagerholé. Here I saw a sandal-wood plantation, and, going on next day into the middle and western zones of the Nalkeri forests, we came across instances of the class of cultivation known as *kumri*, which is carried on by the aboriginal forest tribes, the *Karubars* We encamped again at Nagerholé, and passing on came, on the 20th, to Karmad, and halted at Arimame Bassi. Our next day's march brought us to Tittimatti, on the way to which we passed several coffee plantations. At Tittimatti I left my friends, and accompanied only by my native servant I proceeded, on January 22nd, in bullock carts to make my way to Munjerabad, in Mysore, where I was to meet Mr. R. H. Elliot, and to learn something about coffee cultivation. The journey was neither easy nor uneventful, but it took me through a beautiful stretch of country. I first came to Polybetta and Jemmagundi, where I met Mr. Breithaupt, the secretary to the South Coorg Coffee Planters' Association, and was introduced by him to a number of the planters around, they having, as it chanced, met here on the day of my visit. I was shown over several plantations and saw the picking of the crop and its preparation for market, besides which I heard a great deal from the planters as to what were their main requirements and their experience (para. 362 *et seq.*) I was most hospitably received and set comfortably on my way, reaching Mercara on the morning of January 23rd. Here Colonel Clarke, Commissioner of Coorg, showed me much kindness and facilitated very greatly my rather difficult progress through the, to me, unknown country. After calling on Mr. W. S. Sullivan, I found my way on to Mr. J. S. Trelawney, at Coover Cooly, where I stayed the night. On the 25th I pushed on through Somawarpet and Sanavada Santa to Kodlipet, halting there and fixing up my quarters in a disused schoolroom. Thence, after much difficulty, I succeeded in getting my drivers to take me into Mysore territory, and pushed on to Sucrara Santa. Here I paid a visit to Mr. Butcher, whose coffee plantations I went over, and then proceedrd to Suklespoor, halting there for the night.

Munjerabad, Jan. 27—Feb. 3.

The next morning's march (January 27) brought me to my destination, Bartchinhulla, Munjerabad, where Mr. Elliot met me, and here I remained until February, 3rd. Under Mr. Elliot's guidance I went over his different estates and neighbouring ones, seeing both the cultivation and the preparation of the coffee for sale (para. 363). In this way, and in long conversations on matters concerning Indian agriculture in general, my time was fully and profitably engaged, and the help Mr. Elliot gave me then and since was simply invaluable to me. On February 3rd I had to leave, and proceeded by way of Chickmanglur and Kadur, the Southern Mahratta Railway, and Bangalore, to Madras, which I reached on February 5th.

Madras, Feb. 5–7.

At Madras I was met by Mr. C. Benson, Assistant Director of the Department of Land Records and Agriculture, with whom I stayed. His Excellency the Governor (Lord Connemara) gave me two interviews, and I also had others with the Hon. Mr. (now Sir Henry) Stokes, and the Hon. Mr. Garstin, the two Members of Council; also with Mr. H. F. Clogstoun, Director of the Department of Land Records and Agriculture, Mr. C. A. Galton, Revenue Secretary, Mr. J. D. Rees, private secretary to the Governor, Mr. D. Duncan, Acting Director of Public Instruction, Mr. C. G. Douglas, Examiner of Forest Accounts, and Mr. W. Kiess, Acting Principal of the Saidapet College. In company with Mr. Rees I visited the Saidapet College and Farm on February 6th (paras. 523 and 488). Early on the morning of February 7th a conference was held at Mr. Clogstoun's house, at which, in addition to Mr. Clogstoun, Mr. Benson, Colonel Olcott, and myself, several of the leading native landowners were present, among them being Mr. S. Subramania Iyer, Mr. R. Ragunatha Row, and Dr. M. Iyaswami Pillai: also Mr. P. Rajaratna Mudliar, and Mr. C. K. Subba Row, Sub-assistant Director of Agriculture. In this way I was enabled to get some idea of the most pressing needs of agriculture in Southern India, and to learn in what respects its circumstances differed from those in the more northern parts. I started off the same evening with Mr. Benson on what was to me a very instructive and enjoyable tour through some of the districts in the southern part of Madras.

Shiyali, Feb. 8.

Leaving Madras, we arrived on the morning of February 8th at Shiyali (Tanjore), after crossing the Coleroon river and coming upon the Tanjore delta, where rice was the principal crop then growing. At Shiyali we were met by Mr. C. Sabanayagam Mudliar, who took us over his estate and showed us the rice cultivation upon it (para. 317), and his well-cared-for bullocks and improved iron ploughs (para. 281). In the evening we continued our journey by train,

Madura, Feb. 9.

arriving next morning at Madura. Mr. Ramasubba Aiyar, and Mr. Tillanayagam Pillai, the Deputy Collector, the Mayor of the Municipality, and other gentlemen met us and drove us to the farm which formerly belonged to the Madura Farmers' Club (para. 489), but of which only the dairy-farming portion was maintained. Here our hosts had collected a number of the subordinate revenue officials and of the leading *raiyats*, and with the aid of an interpreter we had a long and, to me, most interesting conversation, or rather conference. Similar gatherings of this kind were held at other stopping places during the tour, and in this way I was enabled to get much information. Mr. Benson also had arranged for representative men to come up from some of the more distant parts, such as Tinnevelly, which, for want of time, I was unable to visit myself.

We left Madura in the evening, and, passing by Trichinopoly, traversed the valley of the Cauveri until, gradually rising to the higher ground, we reached Erode, where soil and cultivation began to alter. Changing here on to the Madras Railway, we continued to rise until we came, in the

Avenashi, Feb. 10–11.

afternoon of February 10th, to Mangalam (Avenashi Road) in the Coimbatore district. We were taken to see the "garden" (irrigated by wells) cultivation, and the system of enclosing fields with hedges (para. 240). Going on to Avenashi itself, we were shown *betel-vine* plantations, the folding of sheep and goats on the land (para. 126), the utilisation of mud from tank beds (para. 132), the growing of perennial cotton (para. 338), the manufacture of saltpetre (nitre) (para. 133), and the breed of Coimbatore sheep. Late in the evening of February 11th we left Avenashi, and, while Mr. Benson went direct to Salem, I struck off alone to Mettapollium, and thence drove up the hill to Ootacamund, reaching this lovely hill station on the morning of the 12th inst.

Ootacamund, Feb. 12–13.

I was unfortunate in not finding Mr. Lawson, the Government Botanist, in residence, but I met Mr. D. Hooper, the Government Quinologist, and also Major-General Morgan, who told me a good deal about tea-growing in the Neilgherries (paras. 357 and 358). The next morning Mr. Hooper took me over the Government cinchona plantations and stores, and also over the Dodabetta Tea Estate. I left Ootacamund on the evening of the 13th, and joined Mr. Benson at Salem on the 14th.

Salem, Feb. 14.

Preparations were then being made for an Agricultural Show that was shortly to be held here. Mr. Benson and I drove out some 10 miles into the country and saw the cultivation both on unirrigated ("dry") land and on that irrigated from "tanks," and that watered by wells ("garden" land). Millets, tobacco, sugar-cane, and many kinds of vegetables were prominent crops, and here I saw the old-fashioned wooden sugar-mills at work (para. 287). On our way back I went to see Mr. Hooper, Deputy Conservator of Forests, and had a conversation with him upon the administration of forests in Madras. The same evening I left Salem and returned to Madras on February 15th, where I paid a second visit to the Saidapet College and had an interview with Mr. Kiess, the acting Principal, after which His Excellency the Governor gave me a second audience.

Madras, Feb. 15–16.

The next day I visited the Hon. Mr. Stokes and subsequently Mr. Van Gaezel, the Chemical Examiner of Madras, leaving in the evening for Bombay, *en route* for Saugor in the Central Provinces, where I was to meet Mr. J. B. Fuller, Commissioner of Settlements and Agriculture, Central Provinces. The first portion of the journey took me through the Bellary and Raichur districts, and I arrived at Bombay on the morning of February 18th.

Bombay, Feb. 18.

I employed the day in interviewing commercial men in Bombay and in getting from them information as to the conditions of the trade in wheat (para. 376 *et seq.*), oil-seeds (para. 388), cotton (para. 338), feeding cakes (para. 127), bones (para. 142), and other manures, as well as agricultural machinery. Among others I met Mr. John Marshall, Secretary of the Bombay Chamber of Commerce, Messrs. Finlay, Muir and Co., Messrs. Volkart Brothers, and Mr. Shallis. In the evening I left again, going on, *viâ* Bhusawal and Itarsi, to Saugor, which was reached on the morning of February 20th.

Saugor, Feb. 20.

Mr. Fuller arrived in camp on the 21st, and meantime I had a look at the cultivation around, a great deal of it consisting of market-gardening. We did not move on until the morning of the 23rd, but then shifted our camp daily until in successive stages we reached Damoh on February 28th. Mr. T. C. Wilson, Settlement Officer, joined us on the march. The principal crops which I saw were wheat, linseed, gram, and other pulses. During the journey I was made acquainted with the systems of Land Classification and of Land Settlement (para. 46) adopted in these Provinces, and I examined in many places the work and maps of the village accountant (*patwari*) staff, and their respective inspectors and district inspectors. We camped at Dongasara on the 23rd, and on the 24th, after passing Sanoda, we halted for the night at Shahpur. Up to now we had been going over the black soil of the Saugor district, but on the 25th we crossed on to the redder soil of the Vindhyan sandstone formation, and arrived at Damoh on the evening of February 27th.

Damoh, Feb. 27.

Jubbulpore, March 1.

I took leave of Mr. Fuller the next morning and pushed on to Jubbulpore. Here I called upon Mr. Lindsay Neill, Divisional Commissioner, and Colonel Van Someren, Conservator of Forests. In the evening I left for Allahabad, arriving at the latter place on the morning of March 2nd.

Allahabad, March 2.

I made the acquaintance here of (the late) Mr. S. A. Hill of the Muir College, one of the few scientific chemists sent out from England to India. I had a long conversation with Mr. Hill relative to the position of scientific men (para. 436), and the prospects of Native students becoming workers in chemical science (para. 423). The same evening I travelled towards Cawnpore, came there next morning, and went out to the Cawnpore Experimental Farm (para. 478).

Cawnpore, March 3–4.

The corn crops were at this time nearly ripe. Mr. J. F. Duthie, Director of Botany for Northern India, joined me in the evening, and next morning we went together to the Cawnpore Farm, where I made the acquaintance of Mr. T. W. Holderness, Director of the Department of Land Records and Agriculture, North-West Provinces and Oudh. We drove out to the Juhi Reserve and the Amramau Farm, to see the experiments carried out on the reclamation of sterile salty land (*usar*) (para. 75). **Aligarh, March 5–6.** In the evening Mr. Duthie and I left for Aligarh, where, on 5th March, we carefully inspected the Chherat Farm (para 75), and on 6th March the Gursikran Farm (para. 75), at both of which places experiments on salty land (*usar*) reclamation were being conducted on a large scale, and were kept under botanical observation by Mr. Duthie. **Meerut, March 7.** On 7th March we left Aligarh, Mr. Duthie going to Saharanpur and I to Meerut. I called on Mr. Whiteway, the Collector, and in the afternoon was driven out to see the splendid market-garden cultivation carried on around the city by theJát, Lodha, and Sani castes (para. 149). I also was shown over the farm belonging to Rai Bahadur Debi Singh, which was formerly an Experimental Farm of the Agricultural Department of the North-West Provinces and Oudh, and on which improved iron ploughs are still employed (para. 476). **Hapur, March 8.** The next morning I drove on to the Babooghur Farm (para. 269), at Hapur, where there is an Army Remount Depôt, and where horse-breeding operations are carried on. Captain Goad, Assistant Superintendent of the Remount Department, took me over the Depôt and Farm, and showed me the horses and the methods of cultivation employed, such as the growing of oats and lucerne, ploughing with iron ploughs drawn by horses instead of bullocks, and the working of wells by horses. **Delhi, March 9-10.** Leaving Hapur on the morning of 9th March, I returned to Meerut, and then went on to Delhi, where I spent a day seeing the sights, and left again on the morning of the 11th for Saharanpur. **Saharanpur, March 11-13.** Arrived there, I met Mr. Duthie and also Mr. Patterson, the Collector. On 12th March Mr. Gollan, the Superintendent, took me over the Saharanpur Botanical Gardens (para. 479), and in the afternoon we went to the Saharanpur Agricultural Show (para, 541), which was specially interesting to me as being the first of the kind I had seen in India. At the invitation of Colonel Dean, Superintendent of the Army Remount Department, I saw the Saharanpur Depôt on the morning of the 13th, the horses here being principally Australian horses ("Walers") imported for the use of medium cavalry and field artillery. Colonel Dean also drove me over the adjoining farm, lucerne and oats, as at Hapur, being largely grown. **Dehra Dun, March 13–18.** After this, I posted from Saharanpur to Dehra Dun, reaching the latter in the evening, and going to Mr. E. Fernandez, then Deputy Director of the Forest School. The next morning I called on Colonel Bailey, the Director, and shortly afterwards Mr. H. C. Hill, Officiating Inspector General of Forests, arrived. The sessional examinations of the Forest School were in progress at this time, and as these were *vivâ voce* ones, I took the opportunity afforded me of attending them, and of ascertaining in some measure what the standard of teaching attained in the Forest School was (para. 52[illegible]). Mr. C. Bagshaw, Conservator of Forests, Central Circle, North-West Provinces, (the late) Mr. W. E. D'Arcy, Assistant Inspector General of Forests, Mr. L. Mercer, Deputy Conservator (Dehra Dun district), and M A. Smythies, Instructor of the Forest School, were present, in additi to Colonel Bailey, Mr. Hill, Mr. Fernandez, and myself. I attended t examinations for four successive days, and was allowed to question number of the candidates in chemistry and in vegetable morpholog (para. 526). I also went over the school buildings, chemical laborator and museums. **Meerut, March 19–20.** On the night of 18th March I left Dehra, going back to Saharanpur, and thence to Meerut, where the Nauchandi Fair and Agricultural Show was being held (para. 541). This interested me greatly, especially the ploughing competition (para. 279), and I met again Mr. Holderness, Mr. Whiteway, and Mr. Muhammad Husain. **Saharanpur, March 21–23.** I returned to Saharanpur the night of the 20th, and spent the next three days there, going over the Botanical Gardens, the Museum and Herbarium, and being taken by Mr. Gollan to see the cultivation of the neighbourhood, which was largely market-gardening of a high class, the cultivators being principally Sánis. At Saharanpur I met Mr. Benson, the District Judge, at whose house I was staying, and who was brother of the Assistant Director of Agriculture, Madras; also Mr. W. Ward Smith, Executive Engineer, Eastern Jumna Canal, from whom I learnt much about the irrigation system of the North-West Provinces. On 24th March, at Mr. Ward Smith's suggestion, I travelled to Hurdwar, and was fortunate enough to find there Mr. King, the Executive Engineer. Mr. King most kindly took me to see the head-works of the Ganges Canal, and the system by which the Ganges is diverted into the canal. After this I drove in a light native cart (*ekka*) along the side of the canal from Hurdwar to Rurki, seeing, on the way, the three great works by means of which the canal is carried, firstly under, then through, and lastly over, the river torrents that cross its path. In the evening I reached Rurki, and took the train for Lucknow, passing *en route* through Rohilkhund and thence into Oudh, arriving at Lucknow on the evening of 25th March. On the 26th I was met by Mr. Muhammad Husain, and went with him to the Lucknow Botanical Gardens (para. 479), which are under the charge of Mr. Ridley, the Superintendent. Next morning I left for Cawnpore, and became the guest of Mr. Holderness, Director of Land Records and Agriculture, North-West Provinces and Oudh. I stayed from then until 2nd April in the Cawnpore district, being taken on daily excursions by Mr. Holderness, as well as minutely examining the Cawnpore Experimental Farm. We went over several Estates belonging to the Court of Wards, and among other places visited Rura, and spent the day in seeing different holdings on either side of the canal (Lower Ganges Canal, Etawah branch). Here the influence of canal irrigation was very marked (para. 88). On 2nd April the corn crops of the experimental plots at the Cawnpore Farm were being brought in, threshed, weighed, and recorded, and I saw this in progress (para. 478). In the evening of the same day I left Cawnpore in company with Mr. W. B. Wishart, on a tour through the indigo-growing districts of Behar. After passing Mirzapore and Chunar, the Ganges was crossed at Mogul Serai on the 3rd April, and we proceeded to Gahmar, where we stayed with Mr. George Fox. Here for the first time I saw the indigo crop growing, and also the machinery used in the manufacture (para. 343 *et seq.*). I also saw in the neighbourhood some excellent market-garden cultivation by men of the *Koeri* caste. From Gahmar we went on to Beheea, in the Shahabad district, and were received there by Messrs. Thomson and Mylne. On the following morning I was driven over a considerable portion of the Beheea Estate, and saw not only the cultivation of sugar cane, but also the manufacture of sugar by the aid of the Beheea mill (paras. 287, 288, 330), the shallow evaporating-pan (paras. 291, 331), and the "centrifugal drier" or sugar "turbine" (para. 292), introduced by Messrs. Thomson and Mylne. Indigo was also largely cultivated on the Estate. I was also shown the records and maps kept by Messrs. Thomson and Mylne for the purpose of managing their Estate, which extends to about 25,000 acres. In the evening we journeyed on to Garaul on the Tirhoot State Railway, and visited the Batoulia Estate and factory, which are under the charge of Mr. F. G. Wilkinson. On the 7th April we took the train on to Mozufferpore, where I was entertained by Mr. A. C. Brett, the district Judge. At Mozufferpore I met a large number of Indigo planters who had come in from the surrounding districts, as also Mr. Schrottky, who had been resident some time in India, and was then regarded by some as a "chemical expert" in the manufacture of indigo (para. 349). On the 8th instant a visit was paid to the Jainpur Estate, Motipore, then managed by Mr. H. Abbott, and here Mr. Wishart and I stayed a couple of days, returning to Mozufferpore on the evening of the 9th. On the 11th instant we went to see the Bhicanpur factory and estate of Mr. G. Richardson, comprising, in all, 7,000 acres. In the evening I set off alone to make my way to Pupri in the Durbhanga district, which I reached next day after riding 30 miles on a trolly kindly provided for me by Mr. Walton, the engineer of the line, the extension from Durbhanga to Pupri not being then completed. At Pupri Mr. Robert Wilson took me over his factory and land, and showed me the different experiments he had made in manuring for indigo (para 348). On the morning of the 14th I started back on my trolly journey to Durbhanga, and thence went by rail right on to Segowlie in the Champaran district, where at Mr. J. J. Macleod's estate (Lall Seriah) I again met Mr. Wishart. We spent two days here, and saw the cultivation in the neighbourhood. Two outlying factories on the

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Pepra, April 18.

Seeraha, April 19.

Beheea, April 20.

Allahabad, April 22-24.

Bâti, April 24-26.

Cawnpore, April 27—May 2.

estate were visited, viz., Rajghat (Mr. D. C. Reid) and Dhokrah (Mr. H. Apperley). On the afternoon of the 16th we all travelled to Motihari, where on the following day there was to be a parade of the Behar Light Horse. Here again I met a large number of the indigo planters of the districts around, as well as Mr. W. D. Blyth, the Collector, and Mr. Seeley, engineer. From Motihari we went on the evening of the 17th April to Pepra, and stopped at Mr. Wyatt's factory. On the 18th we drove from Pepra to Mr. W. B. Hudson's at Seeraha, and went over his estate and factory the day following, leaving in the evening for Bara (Mr. Gale's), and thence by train to Beheea, where I parted company with Mr. Macleod and Mr. Wishart, and paid another short visit to Messrs. Thomson and Mylne. On the morning of the 21st I took the train to Allahabad, and, arriving there in the evening, met Mr. A. J. Hughes, Supervising Municipal Engineer, North-West Provinces and Oudh. It had been arranged, with the consent of the Government of India, that I should visit certain towns in the North-West Provinces where it was proposed to introduce new water supplies and sewerage schemes, and I was to report upon these from a chemical and agricultural point of view. I had originally intended to make a short tour in the Punjab after my return from Tirhoot, but I found the season too far advanced to permit of this, the cold-season (*rabi*) crops being already off the land. Consequently I adopted the alternative plan and visited in succession Allahabad, Cawnpore, Benares, and lastly Naini Tal. At Allahabad, on April 22nd, in company with Mr. Hughes, I saw the new waterworks then in course of construction. In the afternoon I was shown over the Allahabad Grass Farm by Colonel Marriott of the Commissariat Department (para. 215 *et seq*), and he explained to me the system on which the Farm is worked. Grass was then being cut and put into silos (para. 224). On the morning of the 23rd I examined with Mr. Edmonson, the sanitary officer, the system of town-cleansing, the trenching of night-soil upon land at Futtepore Bichwra (para. 149), some little distance out of the town, and another site at Naini which it was proposed to utilise for a sewage farm. At Allahabad I met again Mr. S. A. Hill, also Mr. F. W. Porter, the Collector, and Dr. Hall, Superintendent of the Gaol. I went with Mr. Hughes on the morning of the 24th to see the pumping station and new intake from the Jumna. After this I left Allahabad and travelled with Captain F. C. Chapman to Bharwari on the East India Railway, from which place we drove on to Captain Chapman's Estate at Bâti, crossing the Ganges shortly before coming to our destination. The Estate is in the Province of Oudh, and comprises about 13,000 acres situated along the banks of the Ganges. Here I saw how Captain Chapman, by making a vast embankment and keeping out the Ganges, as well as by draining and pumping, had succeeded in reclaiming and cultivating a large amount of land that was formerly a lake (para. 71). The steam-plough was then at work on a portion still unreclaimed (para. 281). A good deal of ravine land was also reclaimed by terracing and by keeping back surface flow of water (para. 70). Two days were spent here in riding over the property and seeing the villages included in it and also their cultivation. I travelled to Cawnpore on the evening of the 26th April, and put up at Mr. Wishart's. The next morning I went with Mr. Wishart to the *bazár*, and took samples of wheat, the different impurities in which were subsequently separated out for me and determined in Mr. Wishart's office (para. 384). We then drove to the canal side and saw the plot of land called "Buck Sahib's village," on which Kàchhi cultivators use the town refuse, and after that to other land outside Cawnpore where night-soil was being trenched (para. 149).

On the 28th I went over some cotton mills, and on the 29th inspected, with Mr. Hughes, the proposed intake of water from the Ganges, after which I met Mr. Walter Butler (engineer), Mr. F. N. Wright (the Collector), Major Baddeley, of the Army Harness Factory, Dr. Condon (civil surgeon), and Mr. J. Rogers (engineer). The next day Mr. G. B. Allen took me over Messrs. Cooper, Allen and Co.'s Army Boot Factory and then I went on to the Cawnpore Experimental Farm. The next day, after inspecting the site for a proposed sewage farm, Major Baddeley took me to see the Army Harness Factory, and, in the evening, Colonel Worsley and I walked over the Cantonment Grass Farm (para. 214). On May 2nd I met Mr. W. J. Wilson, junior secretary, Irrigation Department, North-West Provinces

Benares, May 3–5.

Lucknow, May 6.

Naini Tal, May 7–16.

Simla, May 19.

and Oudh, and travelled with him the same evening to Lucknow, I going on to Benares. Here Mr. A. R. Wilson, municipal engineer and resident engineer of the Benares Waterworks, took charge of me, and we visited the proposed intake from the Ganges, and on the following day the land intended to be utilised for the purpose of a sewage farm. At Benares I made the acquaintance of Mr. Adams, the Commissioner, Mr. James White, the Collector, and Mr. W. Venis, analyst to the Municipality. From Benares I returned, on May 5th to Lucknow, where I met Dr. Führer, keeper of the Lucknow Museum, and Mr. E. Smith, of the Archæological Department. I went over the Museum, and then drove out to see an artesian well-boring 1,200 feet deep, which it was hoped would give a supply of water for the city. In the afternoon I left again by the Oudh and Rohilkhund Railway for Naini Tal, meeting *en route* Colonel Pitcher, formerly Assistant Director of Agriculture North-West Provinces and Oudh, and Mr. W. J. Wilson, with whom I continued the journey. Naini Tal was reached the afternoon of May 7th, and here I stayed until May 16th. At Naini Tal I met a number of the officials of the North-West Government, and had many interesting interviews. Among these I would mention one with His Honour the Lieutenant Governor (Sir Auckland Colvin), and several with Mr. T. W. Holderness (Director of the Agricultural Department), Colonel Pitcher, Mr T. H. Wickes (chief engineer North-West Provinces and Oudh), and Mr. A. J. Hughes. In addition, I had the pleasure of meeting the Hon. W. Woodburn (Chief Secretary to Government) and Colonel Erskine; also Mr. R. Smeaton (Financial Secretary to Government), Mr. C. J. Connell (Secretary, Board of Revenue). Colonel Thomason, Colonel Harrison (chief engineer Irrigation Branch North-West Provinces and Oudh), Dr. Richardson (Inspector General of Civil Hospitals), and Dr. G. Hutcheson (Sanitary Commissioner). During my stay I was the guest of Mr. W. J. Wilson, whose experience in irrigation as well as in experimental work on reclamation of salty land (*usar*), and on the establishment of "Fuel and Fodder Reserves," was of great advantage to me. Mr. A. Grant, supervising engineer Irrigation Department North-West Provinces and Oudh, was also staying there. An inquiry, similar to those at the other towns in the North-West Provinces which I had visited, was then in progress, and, accordingly, I examined the proposals both for utilising a fresh water supply and for disposal of the sewage of this hill station. On May 17th I left Naini Tal, calling, on my way down the hill, at Mr. S. L Whymper's, an old school-fellow of mine. Taking the train at Kathgodam, I travelled on to Bareilly, and thence, *viâ* Saharanpur, to Umballa, which was reached by the evening of May 18th. Posting from here through the night, I came next morning to Kalka, and finally arrived at Simla early in the afternoon of May 19. I stayed in Simla from that date until July 14. I employed this interval in putting together the notes I had taken during my tour, in reading Settlement and other Reports of the districts I had visited, as well as the principal Government papers upon subjects with which my inquiry was more specially concerned. I had also the opportunity of meeting a number of the high officials of Government, all of whom received me most kindly and gave me much assistance. His Excellency the Viceroy especially showed much interest in the matter of my inquiry, and gave me renewed interviews. The Members of Council, Sir David Barbour, Sir George Chesney, Sir Charles Elliott, the Hon. Mr. Hutchins, and Sir James Lyall also allowed me to discuss with them the views I had formed. Among other officials whom I met, and by whose experience I benefited greatly, were the Hon. W. C. Benett (then acting for Sir Edward Buck in the Agricultural Department), Colonel Forbes (Inspector General of Irrigation). General Badcock (Commissariat Department), Mr. Muir-Mackenzie (Under Secretary Agricultural Department), Mr. H. C. Hill, Dr. George Watt, Mr. Harvey James, Mr. J. F. Finlay, Mr. J. E O'Conor, Mr F. A. Robertson (Director of Agricultural Department, Punjab), Mr. S. A. Hill, and Major Elliott (Commissariat Department). The library and records of the Agricultural Department were placed at my disposal, and Mr. Tucker, the Registrar, helped me in every way he could. Before leaving for my second tour, I drew up my general conclusions in the form of "Preliminary Notes," which were printed and circulated, and subsequently discussed at the Agricultural Conference in the following October.

Second Tour.
1890.

Second Tour, July 14th to Sept. 12th 1890.

Simla, July 14.
Jeypore, July 17–18.
Ahmedabad, July 20–21.
Nadiad, July 22.
Baroda, July 23.
Máhim, July 24.
Bombay, July 25.
Poona, July 26–28.

Just after the rains had set in I started off again on my travels, and leaving Simla on July 14th in company with Dr. Hendley, of Jeypore, made my way again to the plains. Passing by way of Delhi, we arrived on the evening of July 16th at Jeypore. Here I had an agricultural talk with the chief Member of Council of the Jeypore State, Rai Bahadur Kamtee Mookerjee (paras. 110, 212), and after seeing, under Dr. Hendley's guidance, the Museum, Hospital, School of Art, the Jeypore Cotton Press, &c., I went on to Ahmedabad, arriving there on July 19th. I stayed with Mr. H. E. M. James, the Commissioner, and the next morning we were joined by Mr. Ozanne (Director of Agriculture, Bombay), and Mr. Middleton (Professor of Agriculture, Baroda College), who were to be my guides and companions in my tour through the Bombay Presidency. We spent two days at Ahmedabad seeing the cultivation of the neighbourhood, including irrigation of land from tanks, also the growing of perennial cotton, the sowing of rainy-season crops, and the preparation of land for rice, and the transplanting of rice. From Ahmedabad we passed on, early on the 22nd, to Nadiad, where we were joined by Mr. Kacherao Jadhava, a Native in the service of the Gaekwar of Baroda, and formerly a student at Cirencester College. We were met at Nadiad by Rai Bahadur Becherdas Viharidas Desai, a leading agriculturist, by Mr. Motibhai, the President of the Municipality, and by the Secretary of the Nadiad Agricultural Association. After visiting a store in the town established for the purpose of selling pure seed (para. 310) we went to the Experimental Farm of the association (para. 484), and to Mr. Becherdas's own farm. After this we went out again to see the cultivation of the neighbourhood, the fields enclosed with hedges (para. 240) and with borders of grass around them (para. 211) being prominent features. We also visited here a hospital (Pinjrapol) for disabled and dying cattle. The same evening we left for Baroda, and stayed there with Mr. F. A. H. Elliott (Survey Commissioner). On the next morning we went over the fields out of which it was proposed to form an Experimental Station and Farm in connection with the Baroda College (para. 485). After breakfast we drove to the Gaekwar of Baroda's palace, and had a long interview with His Highness, principally upon the subject of agricultural education. Subsequently we visited Mr. Kacherao Jadhava's experimental station, and his laboratory (para. 485), and still later the Baroda College (para. 521), meeting there the Principal, Mr. G. S. Tait. At Baroda I also met the Resident, Sir Harry Prendergast, and Mr. W. S. Price, superintendent of the Baroda Survey. In the evening we left, and travelled to Palghar in the Thána district, whence we drove to Máhim. Here we saw the splendid "garden" cultivation, the growing of sugar-cane, plantains, ginger, *betel-vine*, and other remunerative crops (para. 119), besides the system of seed-bed formation, known as *ráb* (para. 137), for rice and millet (*nágli*) growing. At Máhim we met Mr. Dhondo Vinayek Dandekar, a leading landed proprietor, Mr. Padmaker Narayan, *Mamlatdar* of Máhim, and many others. In the afternoon we drove back to Palghar, and thence by train to Bombay. The next day I called on Mr. John Marshall, of the Chamber of Commerce, and had a long talk with him on the subject of wheat-cleaning (para. 376 *et seq.*), and oil-seed cleaning (para. 388) and upon the trade in cotton (para. 338). From Messrs. Croft, Wells and Co. I gathered information on the collection and export of bones (para. 142), from Messrs. Volkart Brothers on trade in cotton, bones, and manures, and from Messrs. Glade and Co., on the manufacture and trade in oil-cakes (para. 127). On the 26th inst. we went on to Poona, I leaving the others at Kirkee, as I was to be His Excellency the Governor's (Lord Harris) guest at Ganesh Khind. Mr. Lee Warner, Political Secretary to Government, was also staying at Ganesh Khind at the time. With Mr. Ozanne I went over the Ganesh Khind Gardens (para. 486), and on July 28th drove with him and Mr. Middleton to Mundwa, a few miles out of Poona, to see the sugar-cane and other cultivation of the district which is carried on by canal irrigation and the use of night-soil (poudrette) (para. 149). We also went over a distillery where spirit is made from the fruit of the *Mahua* tree. In the afternoon I met at the office of the Department of Land

Records and Agriculture Mr. Bhimbhai, the Assistant Director, and later on we held a conference with the principal landowners, agriculturists, and native officials of Poona. Among those present, besides Mr. Ozanne, Mr Middleton, Mr. Bhimbhai and myself, were Rai Bahadur Mahdeo Govind Ranade (Judge under the Deccan Relief Act), Rai Bahadur Yeshwant Moreshwar Kelkar (Oriental Interpreter to the Government), Mr. Dorabji Padamji (President of Poona Municipality), Mr. Naoroji (manager of Reay Paper Mills), Mr. Namjoshi and Mr. Ghotandekar, editors of native papers, Mr. Kupaswami Mudliar (secretary of the Agri-Horticultural Society of Western India), Mr. Dandekar (Educational Inspector of the Berars), Mr. Nata and Dr. Ghole, landowners. We had a long and interesting conversation and interchange of views, more especially on points connected with forest administration, questions of irrigation, and agricultural education.

Belgaum, July 29–30.

In the evening we started off by train for Belgaum, which we reached on the 29th July. and stayed with Mr. A. Keyser, the acting Commissioner. Mr. J. Fairlie Muir, the Collector, met us later on, and we went out to see the extensive rice-growing by the tank irrigation system. At the Collector's office was a large collection of the implements in common use in the district, and from the District Deputy Collector, the Hon. Gahrshitapa Virbasapa, we heard of the success which had attended the efforts to popularise the system of Government Advances (*taccavi*) for agricultural purposes (para. 109). Next day we inspected the farm attached to the Agricultural Class of the High School (para. 522), and then went to see the market-gardening around the town. At noon we left for Bellary, passing *en route* Dhârwar, Gadag, and Hubli.

Bellary, July 31.

At Bellary, where we arrived on the morning of 31st July, Mr. A. Sabapathi Mudliar met us and took us to his farm, where he showed us the utilization of prickly pear as green-fodder (para. 236), the Swedish ploughs which he uses on his estate (paras. 277, 281), and the preparation of bones for manure (para. 143). Owing to the late coming of the monsoon and absence of irrigation there were hardly any crops on the ground, so we did not stay long here, but retraced our steps to Hospet, which we came to in the afternoon.

Hospet, July 31.

Mr. C. H. Goud met us here, and under his guidance we saw the rice and sugar-cane cultivation of the district. The enclosure of the fields with trees (para. 240), and the lopping of the trees for supplying green manure for the rice fields, para. 136), as also the growing of grass for cattle along the water-channels (para 211), were peculiar features here. Irrigation is by means of channels taken off from the River Tungabadra, and the cultivation is excellent; the cultivators are mostly of the Lingayat caste. Iron sugar-mills are used extensively here (para. 289). We were entertained at Hospet by Mr. F. Parsons, Head Assistant Collector, and the day following visited the ruins of Humpi.

Humpi, August 1.

In the evening we left by train on the return journey to Poona, but Mr. Middleton and I halted a day at Bijapur, where we called on Mr. Fleet, the Collector, and were shown much kindness by Mr. F. Goldsmid, Superintendent of Police.

Bijapur, Aug. 2–3.

Poona, Aug. 4.

Continuing our journey we reached Poona on the morning of 3rd August, and, meeting Mr. Ozanne again, we went over the Poona Experimental Farm together. After this I had a long interview with Mr. Wroughton, Conservator of Forests, with reference to forest matters in their relation to agriculture in the Bombay Presidency (para. 174). In the afternoon Mr. Middleton and I went over the College of Science, and then once more with Mr. Woodrow to the Experimental Farm, where we met several of the pupils of the Agricultural Class.

Kalyan, Aug. 5.

In the evening Mr. Ozanne, Mr. Middleton and I left for Kalyan, where we halted a few hours to see the rice and millet (*nágli*) cultivation in these wet parts of the Western Ghâts. Then resuming, we travelled up the Tull Ghâts into the Nasick district and alighted at Igátpuri. Here we saw more rice and millet (*nágli*) cultivation, some of it by the seed-bed system called *ráb*, there being no irrigation, but simply very heavy rainfall. Buffaloes were here the plough cattle (para. 260).

Bhadgaon, Aug. 6–7.

In the evening we took the train again and reached Pachora on the morning of 6th August, going on thence to the Bhadgaon Farm, which we reached after crossing four different rivers; these were then in flood, and presented considerable difficulty to our passage. Arrived at the Farm we went carefully over it (para. 482), seeing then the rainy-season (*kharif*) crops, just as on my previous visit I had seen the cold-weather (*rabi*) crops. We also saw the herd of Mysore cattle (para. 255), the formation of a *babul* (*Acacia arabica*) plantation (para. 186), and the making of silage (para. 226). The next day we left, and, after visiting a cotton-cleaning (*ginning*) factory *en route*, at Pachora I parted company with Mr. Ozanne and Mr. Middleton.

Nagpur, August 8-10.

Taking the train on to Nagpur, I arrived there on the morning of the 8th, and went to Mr. J. B. Fuller's, where I stayed this and the next two days. At Nagpur I had an interview with Mr. (now Sir Alexander) Mackenzie, the Chief Commissioner, and among others I met and discussed agricultural matters with Mr. J. Neill (Judicial Commissioner). Mr. A. Munro (Director of Public Instruction), Colonel Van Someren and Mr. R. T. Thompson (Conservators of Forests), and Colonel Scott. Mr. Fuller took me over the Nagpur Experimental Farm (para. 480), the management of which is in the hands of Mr. Mahaluxmivala. After this, we inspected the Agricultural Class and museum (para. 524), Mr. Joshi, formerly a Poona student, being teacher of agriculture. At other times we visited the plots of land cultivated by the students of the Agricultural Class, and also the land outside the town where the night-soil and town-refuse are utilised by the *Káchhis* and other cultivators who have followed their example (para. 149). On the evening of August 10th I left Nagpur for Calcutta. At Allahabad I met Mr. A. J. Hughes, Supervising Municipal Engineer North-West Provinces, and travelled part of the way with him, hearing from him what had been done in furtherance of the sanitary schemes we had discussed before. It was now the middle of the rainy season and a great part of the district passed through was covered with water.

Calcutta, August 13.

Arriving at Calcutta on the morning of the 13th, I spent the day with Mr. Finucane, Director of Land Records and Agriculture, Bengal, and, in the evening set off with him and Mr. P. Nolan, Revenue Secretary, for a short tour in Eastern Bengal. The train took us as far as Goalundo, Dr. Comins, Superintendent of Emigration, travelling with us. At Goalundo we embarked on the steamer for Serajgunge, and during the sail up the Brahmapootra river we saw the numerous villages on the islands dotted about on the river or along its banks, together with their rice and jute cultivation (para. 374).

Serajgunge, August 14-17.

At Serajgunge, Mr. Cuthbert Macdonell, manager of the Serajgunge Jute Mills, and his assistant, Mr. Ogbourne, met us and took us off in their steam launch to their house. We stayed here until the 17th, and met Mr. Andrew Hannah, Mr. S. Gowan, and other jute commission-agents. On the 15th inst. we took a long trip of about 30 miles in the steam launch to Solanga, going up the streams then intersecting the country and noting the jute and rice growing everywhere along the banks. On the 16th we saw over the Serajgunge Jute Mills, and in the afternoon Mr. Finucane and I went about in a boat and called at several of the islands for the purpose of seeing how the cultivation was carried on, as well as the preparation of the jute and its packing for market. On the 17th we left Serajgunge, and returned to Calcutta on the 18th.

Calcutta, Aug. 18-19.

The same afternoon I went with Mr. Finucane to inspect the Seebpore Experimental Farm (para 493), and met here Mr. Basu and Mr. Banerji of the Bengal Agricultural Department. The day following, I had an interview with Mr. R. Blechynden, secretary of the Agricultural and Horticultural Society of India, in relation to the coming of a chemist to India to enquire into problems connected with the cultivation and manufacture of tea (para. 361).

Dumraon, Aug. 20-21.

In the evening Mr. Nolan, Mr. Finucane, and I left for Dumraon, where we were to meet His Honour the Lieutenant Governor of Bengal, Sir Steuart Bayley, then on tour. This we did, and with His Honour went round to see the school, hospital, museum, and other places, subsequently meeting again at a dinner given in the Lieutenant Governor's honour. Among the party were Mr. C. C. Stevens, Officiating Chief Secretary to Government, Mr. W. Kemble, Opium Agent, Bankipur, Mr. J. Charles, Judge of Shahabad, and Mr. J. Bernard, Officiating Collector, Shahabad). On the 21st we went over the Dumraon Experimental Farm with Mr. Basu (para. 492), and subsequently had an interview with the Maharajah of Dumraon and Rai Bahadur Jai Prakash Lal, the manager of the Dumraon Estate (*Raj*). In the afternoon Mr. Finucane and I left Mr. Nolan and the others and crossed the Ganges at Mokameh, proceeding into Tirhoot for a short tour there in order to see the manufacture of indigo (para. 349). We first went to Bara, and

Seeraha, Aug. 22–23.
Motihari, Aug. 23.
Bettiah, Aug. 24.
Allahabad, Aug. 26.
Cawnpore, Aug. 27.
Hissar, Aug. 29–30.
Ferozpore, Aug. 31—Sept. 1.
Changa Manga, Sept. 2.

drove to Mr. W. B. Hudson's at Seeraha, where we arrived on the morning of August 22nd. I was just in time to see the cutting and steeping of the indigo plant, and the subsequent preparation of the dye in its different stages. Leaving Seeraha on the 23rd we went on to Motihari, and stayed with Mr. W. D. Blyth, the Collector. Here I met again Mr. Apperley and Mr. Seeley. On the morning following, we went with Mr. Blyth by train to Bettiah, and were the guests of Mr. T. M. Gibbon, manager of the Bettiah Estates. The country here was much flooded, but we saw the cultivation as far as we could, and I had much interesting conversation with Mr. Gibbon. The following morning we left again, and at Motihari I ended my tour with Mr. Finucane, and proceeded alone to Allahabad, which I reached on August 26th. Here I visited Mr. S. A. Hill and Captain F. C. Chapman, and went over the Allahabad Grass Farm again with Captain Hallowes and Sergeant Meagher (para. 215). A large quantity of silage was being made at the time (para. 224). I took the night train to Cawnpore, and, arriving there on the 27th, I drove to the Experimental Farm and made another inspection of it with Mr. Lachman Parshád, the personal assistant to the Director. After calling on Mr. Wishart I left again for Hissar, where on the 28th inst. I was to meet Mr. F. A. Robertson, Director of Land Records and Agriculture, Punjab, and to make, under his guidance, a short tour in the Punjab. I duly arrived at Hissar and met Mr. Robertson, we both staying with Captain Marrett, Superintendent of the Hissar Cattle Farm. On the morning of the 29th Captain Marrett drove us over the Grass Farm for some 10 miles to Khairwan, where we saw the different herds of cattle kept on the farm (*see* para. 254). On our return we found Colonel Patch (Commissary General, Northern Circle, Bengal) and Captain (now Major) Wingate (Special Forage Officer), and had a conversation upon the system of Grass Farms (para 215). We then went over the Home Farm, and saw the young stock, as also the growing of lucerne and other green crops (para. 236), and the making of silage (paras. 224, 226). Next day we met Mr. A. Anderson (Deputy Commissioner), and went with him to see the cultivation of the neighbourhood, both on canal irrigated and on unirrigated ("dry") land. Later on we visited the sheep and goat-breeding Farm (para. 270), and left in the evening for Ferozpore, arriving there early on August 31st. Mr. E. B. Francis (Deputy Commissioner) took charge of us, and drove us round to see the cultivation near the town, as well as the system of inundation canals (para. 92). On September 1st we drove out towards Ludhiana, and saw several villages where the cultivation was mainly carried on by men of the Ját caste. In the afternoon we left for Changa Manga, and put up at the Forest bungalow. Mr. A. V. Munro, Assistant Conservator, and Mr. Fazil Din, Sub-assistant Conservator, took us over the "reserves" (paras. 177, 221) and grass runs (*rukhs*), as also to the more distant *rukh* Jelleke.

Multan, Sept. 3.
Rashida, Sept. 4.
Lahore, Sept. 6.
Gujrát (Punjab), Sept. 7.

In the evening we took the train to Multan, and got there early on September 3rd, going to the Deputy Commissioner's, Mr. H. C. Cookson. Mr. Cookson drove me round the town, showing me the cultivation and the inundation canals (para. 92), and later on to the more outlying parts, where, among other things, I saw the manufacture of indigo according to the native method. On September 4th Mr Cookson, Mr. Smith (Executive Engineer, Sidhnai Canal), and I, went by train to Rashida, and then rode out to see the system of canal distribution and some of the villages which had been established along the Sidhnai Canal since the latter had been brought to the district (para. 86). Previous to this only a small part of the area had been under cultivation. On the morning of September 5th Mr. Cookson and Mr. Smith returned to Multan, and I continued my journey with Mr. Robertson to Lahore, Montgomery being passed on the way. On the 6th inst. Mr. A. V. Munro met us again, and took us over the Shahdara plantation (para. 177), a little outside Lahore. After this we went to the veterinary school, dispensary, and hospital, and saw the stallions of the Horse-breeding Department which are kept here (para. 269). Starting off again in the evening by train, Mr. Robertson and I reached Gujrát (Punjab), and were met by Mr. E. B. Steedman, Deputy Commissioner, and formerly Director of Agriculture, Punjab, and by Captain

Davies, Settlement Collector. The following morning we rode out and saw the crops, here mostly irrigated from wells. We passed also large tracts of land flooded with silt from the mountain streams and channels, and which form the rich wheat-growing stretches of these parts (para. 138). Splendid cattle, which came originally from Hissar, were seen here (para. 254), and there was also a Depôt of the Horse-breeding Department (para. 269). Mian Mir, Sept. 8. We left Gujrát at night, and arrived next morning at Mian Mir, where we halted to see one of the military Grass Farms. The one we visited was *rukh* Terah, and the grass was then being cut, and a great deal was being packed into silos dug in the ground (para. 229). Amritsar, Sept. 8–9. From here we went on to Amritsar, and became the guests of Mr. J. A. Grant, Deputy Commissioner. Mr. Grant took us in the afternoon to see the town, its temples, &c., and also the system of town sanitation so successfully adopted here (para. 149). On September 9th we were out early, and spent a long morning in seeing the extensive market-garden cultivation carried on all around Amritsar by the help of irrigation from the canal (Bari-Doab Canal), and the night-soil and sweepings from the town (para. 149). Vegetables were being raised in great profusion; also sugar-cane and maize. We passed on to a village, Sultanwind, on the other side of the canal, where canal irrigation is only partial, and wells are dug for supplementing it. Returning to Amritsar we made a closer inspection of the sanitation system (para. 149), and went to other land on which the sullage water is pumped. Later in the day I met Mr. E. Nicholl, the Secretary to the Municipal Committee, and he explained to me in detail what had been done. In the evening we left for Kirtapoor, where Dr. Kapurthala, Sept. 10. Warburton met us and drove us out to Kapurthala. Here we were met by Major Massy, the Superintendent of the Kapurthala State. We received a visit next morning from the Rajah of Kapurthala, which we returned in the afternoon. Meean Aziz Bukhush, the Collector of the State, also came and had an agricultural conversation with me. I have to acknowledge much valuable information and many useful suggestions given to me by Major Massy during our stay. Later on we drove out to see the cultivation and the plantations that had been started round the town. On the morning of September 11th we left Kapurthala, and drove, *viâ* Hoshiarpur, Sept. 11. Jullundur, to Hoshiarpur, a distance of 36 miles. The road took us past excellent cultivation, and we made several halts on the way to see this or that object of special interest. Cultivation by well irrigation was a marked feature, and we saw a great deal of digging of wells going on, the wells, in places, being quite near the surface. Sugar-cane was extensively grown. We passed some wide sandy tracts known as the "choh" lands (para. 71), where no cultivation exists, but the soil is covered with transported, or "blown" sand. Arrived at Hoshiarpur, Mr. Robertson had the village records, and maps of the village accountants (*patwaris*) brought for my inspection: later on we drove out to see the cultivation around the town. Sugar-cane was the principal crop growing, and large quantities of manure are used for it, the night-soil and town refuse being assiduously saved (para. 149). Cactus hedges encircle the fields, and firewood is fairly abundant. An Arab stallion belonging to the Horse-breeding Department is kept here (para. 269). After calling on Colonel Wood, the Deputy Commissioner, we left Hoshiarpur and drove back the 25 miles to Umballa, Sept. 12. Jullundur, from which we took the train to Umballa, where we arrived on the morning of September 12th. We halted a short time to see the cotton crops which grow here on unirrigated land (wells being hard to dig), and Simla, Sept. 12. then drove to Kalka, finally concluding my second tour by reaching Simla on the evening of September 12th.

I now had to settle down to prepare for (1) the Agricultural Conference, which was to meet at Simla on October 6th and following days; (2) the compilation of my Report. My work was, however, delayed for a time by an attack of malarial fever, contracted, doubtless, during my Punjab tour with Mr. Robertson, for Mr. Robertson was laid up at the same time, and unfortunately was ill for some time afterwards. My attack lasted but a short time, and on getting well enough, Dr. Watt took me with him for a very enjoyable three days' trip to the Suni Valley, and the basin of the Sutlej river. On my return I found myself once again among the officials whom I had met in the previous May and June, and who had given me so much help. In addition I met Mr. R. S. Whitall, Mr. McIntyre, and Mr. J. H. Lace, all of the Forest Department.

Mr. J. B. Fuller (Commissioner of Settlements and Agriculture, Central Provinces), arrived in Simla on September 29th, previous to the sittings of the Agricultural Conference, and on October 4th Sir Edward Buck returned from furlough, and resumed the duties of his office. Mr. Clogstoun, Mr. Nolan, Mr. Ozanne, Mr. Finucane, Dr. Theodore Cooke, and Mr. Middleton, and other members of the Agricultural Conference arrived subsequently, and the first meeting was held on the afternoon of 6th October. There were seven sittings in all, and the Conference broke up on October 13th, after giving a general approval to the proposals which, in the form of "Preliminary Notes," I had submitted for consideration. The subjects which chiefly engaged the time of the Conference were, the appointment of an Agricultural Chemist for India, the conduct of experiments at Government Farms, and Agricultural Education. The Conference over, and the members dispersed, I returned to my former work, and read through several Settlement Reports of the districts which I had visited, and made copious extracts from Government Papers and Records which I found in the library of the Revenue and Agricultural Department. On November 1st I began the actual writing of my first Report, and from now until the 23rd instant, when I left Simla, I wrote and had printed off the first twelve chapters, in such a form that I was able, before leaving India, to send them to different people for perusal. In the correction of these proofs Sir Edward Buck, Mr. J. B. Fuller, Mr. J. E. O'Conor, Mr. Ozanne, Mr. Finucane, and Mr. H. C. Hill, gave me most valuable help.

Agricultural Conference, Simla, Oct. 4–13.

Third Tour, November 3rd 1890 to January 10th 1891.

Third Tour.

I left Simla on November 23rd, and after reaching Umballa, took the train for Ajmere, where I had arranged to meet Mr. H. C. Hill, and to see the Ajmere-Merwara forests (para. 181). I got to Ajmere very early on the morning of November 25th, and later on set off with Mr. Hill to the Nagpahr forests, where we saw the "reserves" that had been made on the hill sides around Ajmere. We then came down the hill again, and went first to Pokhar, where nurseries are formed, and then to Pushkar where a Fair was being held, and at which there were a great number of horses, many of them very good. In the afternoon Mr. Hill and I went to the *Mohwa bir* (para. 181), another "reserve" on the other side of Ajmere. We made an early start next morning, took the train to Biawar, and rode until we came to the "Chang reserve," which is principally used for supplying firewood, small timber, and grass, as well as for grazing in time of drought. This we went carefully through (para. 181). Sirdar Hira Singh, the Sub-assistant Conservator, was present to point everything out to us, and we ended up at Sendra. From this place I proceeded next morning alone, but met Sir Edward Buck in the train, and we went on in company to Bombay, taking the train in the afternoon to Poona. In the train with us were Dr. Steel and Dr. Grainger, of the Veterinary Department. Mr. Ozanne and Dr. Theodore Cooke met us at Poona, and the same evening I made the acquaintance of Dr. Lingard, who had lately arrived at Poona as Imperial Bacteriologist, and I was shown by him his newly-established Bacteriological Laboratory. By invitation of His Excellency the Governor of Bombay (Lord Harris), Sir Edward Buck and myself went out to Ganesh Khind, and stayed there a day. At Poona I met Sir Charles Pritchard, Member of the Bombay Council, Mr. J. B. Hallen, Superintendent of Horse-breeding Operations, and Mr. Mollison, the newly-appointed Superintendent of Government Farms, Bombay. We stayed at Poona until December 3rd, when Sir Edward Buck and I returned to Bombay. Here I left Sir Edward Buck the same evening, and travelled through to Calcutta, arriving there on the morning of December 6th. At Calcutta I met again many of the officials whom I had previously seen at Simla, including Mr. H. C. Hill. Mr. D. B. Allen, a diploma holder of Cirencester, Captain Chapman, Mr. Bamber, and other gentlemen interested in agriculture, came to see me during my stay at Calcutta, and I also visited Dr. George King at the Botanical Gardens, Howrah. On December 24th, Colonel Sergeaunt

Simla, Nov. 23.

Ajmere, Nov. 25.

Ajmere reserves, Nov. 26.

Bombay, Nov. 28.

Poona, Nov. 28—Dec. 3.

Bombay, Dec. 3.

Calcutta, Dec. 6–24.

Darjeeling, Dec. 25–27.

(Director General of Railways), and Colonel Begbie (Accountant General Public Works Department), took me with them on a trip to Darjeeling, which was most enjoyable. I spent one of the days of my stay there in going over tea plantations. Mr. G. W. Christison, manager of the estates of the Leebong Tea Company, took me over the plantations and factory, and gave me every possible information both as to cultivation and to manufacture (para. 357). On returning in the evening, I met Mr. G. A. Maclean, a tea planter in the neighbourhood, who had been a fellow-passenger with me from England. Lieutenant Bower, the noted traveller, was then also at Darjeeling. We left Darjeeling on December 28th and reached Calcutta on the morning of the 29th, and then I paid a long visit to Dr. Warden, Professor of Chemistry at the Medical College. From now until January 6th, when I left Calcutta, I employed my time in drawing up an Abstract Report to Government, which has since been printed and circulated. Sir Edward Buck returned to Calcutta on January 1st, and again gave me much help in my work. His Excellency the Viceroy gave me a final interview on January 3rd, as also did Sir Charles Elliott (then recently made Lieutenant Governor of Bengal), the Hon. Mr. Hutchins and other officials. Then, having settled all my affairs, and handed in my Abstract Report to Sir Edward Buck, I left Calcutta on the evening of January 6th for Bombay, Sir Edward Buck coming to see me off. Mr. Duthie travelled with me as far as Bhusawal. I reached Bombay on the evening of January 9th, and here Mr. Ozanne met me again. We went out to see the dairy establishments that had been set up in Bombay for selling butter made from cream obtained by the "separator" and of skim milk (para. 265), and, afterwards, with Mr. Boileau, of Messrs. Croft, Wells & Co., we went by train to Thána and saw there the bone-grinding mills of the last-named firm (para. 145). On my return I called on Messrs. Volkart Brothers and other business houses. On January 10th, Mr. Ozanne, Mr. Boileau, and I, drove out to the Mazagon Dock and the Frere Bunder and saw the grinding of bones for use as manure, as it is conducted by the native merchants (para. 145). It was then time for me to leave, and at noon I went on board the Peninsular and Oriental Steamship "Siam," and quitted India after a stay of exactly thirteen months in the country, during which time I had received kindness on every hand, which I shall always remember gratefully, and opportunities for gaining knowledge which it rarely falls to the lot of anyone to enjoy.

Calcutta, Dec. 29—Jan. 6, 1891.

1891:

Bombay, Jan. 9–10.

Left India, Jan. 10.

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